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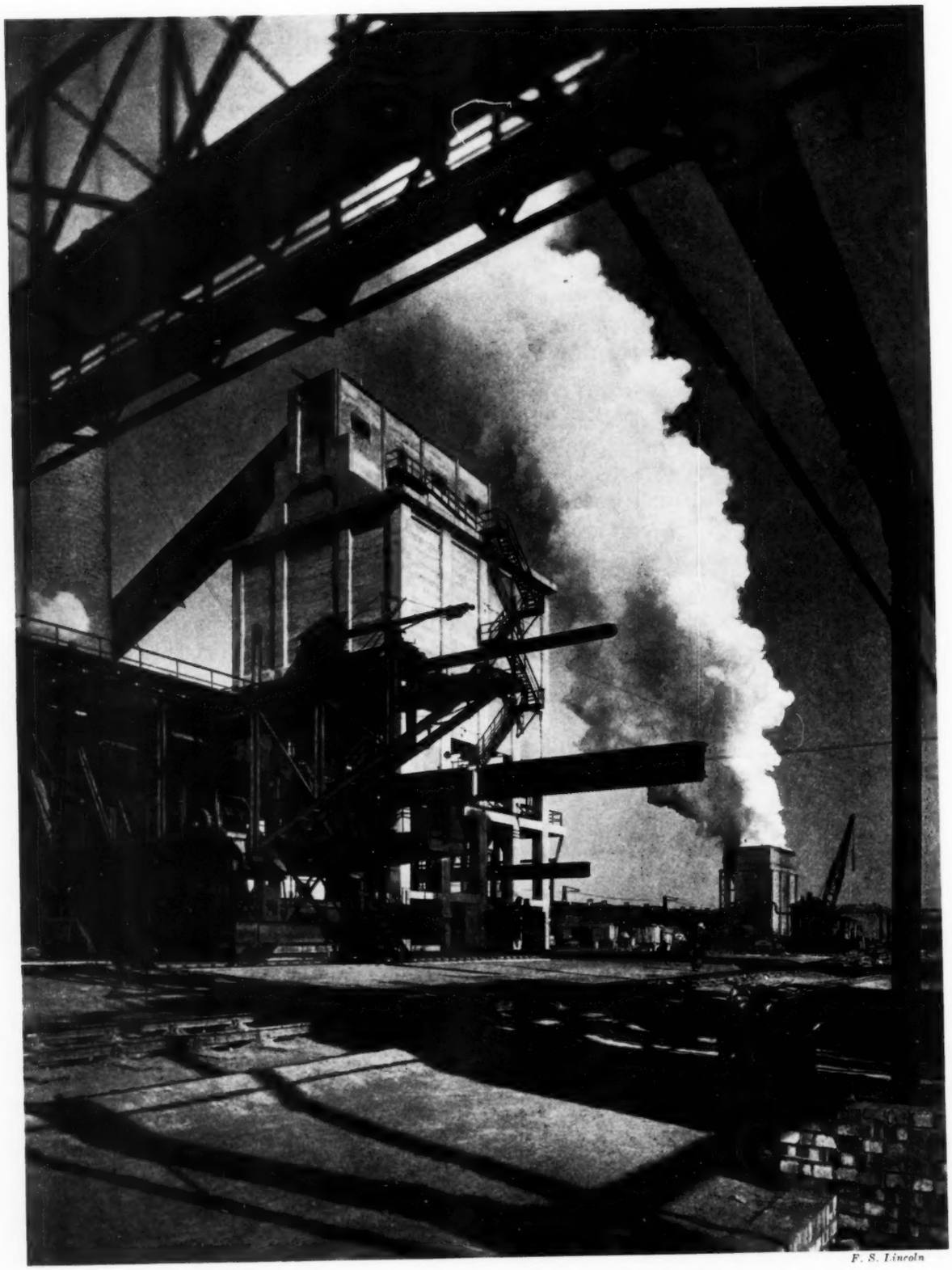

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MECHANICAL ENGINEERING

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GEORGE A. STETSON, *Editor*

Four Meetings a Year

INAUGURATION of the new program of four meetings a year with the first National Fall Meeting of The American Society of Mechanical Engineers was accomplished at Erie, Pa., early in October. Members of the Society who were not present may be able to reconstruct some of the atmosphere of that occasion by reading the account of it that appears on pages 873 to 876 of this issue.

Whatever misgivings may have been held of the practicability of the four-meeting program were soon dissipated, in so far as those who attended were concerned, when the effects of an excellent program of technical sessions got under way the first morning and the cordiality of the Erie Section impressed itself on every one. By the end of the day when visitors had lunched together, seen some of Erie's prominent industrial plants, and attended the stimulating education session in the evening the meeting had taken on that atmosphere which even the most casual observer recognizes as marking it for success.

It is obvious that for success one requisite among many must be a program of papers of national-meeting character that will bring out discussion making attendance worth-while. This essential requisite had fortunately been met with results that should make it easy to secure papers of high quality for future Fall and Spring meetings, thus paving the way for the relief of crowded Annual and Semi-Annual meetings of the Society. By maintaining the excellent example set at Erie, attendance at these newer National meetings is bound to increase, for the word will get about that such gatherings are important additions to Society meeting schedules.

Undoubtedly, too, there were many at Erie who went away with renewed confidence in the Society's future and with a resolution to be present at the Annual Meeting in New York early in December. The program of this meeting, tentative, it is true, but as accurate as can be announced so far in advance, will be found in the A.S.M.E. News Section of this issue. It is rich in variety and quality of subject matter, and is interspersed with the nontechnical but important features so highly regarded by regular attendants at these largest of Society gatherings. More than 2000 members and guests will be present. Mechanical Engineers will not wish to miss this meeting. Note the date now—December 6 to 10—and arrange personal schedules accordingly.

Our Cities

ANOTHER report of the National Resources Committee was made public during the month of September. Entitled "Our Cities, Their Rôle in the National Economy," it was prepared by the Urbanism Committee and is said to be the first major national study of cities in the United States. It is characteristic of the present-day concern felt by the federal government for questions of national economy traditionally considered in the past as being of state and community interest and, on this account, its reception will be greeted with enthusiasm or misgivings in accordance with the reader's individual enthusiasms or misgivings on the subject of a strong central government and the extent of its spheres of influence and control. Regardless, however, of personal opinions and convictions on such matters, the material presented in the report is a convenient and welcome compilation of the factors involved in the problems of urbanism.

In the foreword of the report are presented four national trends of the past few decades that are said to have produced unplanned and unexpected changes affecting the entire pattern of national life. These are: (1) A distinct and sudden shift in the nation's status from a predominantly rural to an urban people; (2) an unprecedented mobility, arising from the harnessing of steam, electricity, and the internal-combustion engine, to men and materials, that is responsible for this phenomenal urban development; (3) not only a concentration of the nation's population but a centralization of enterprise in cities, metropolitan districts, urban satellites, and industrial areas; and (4) the effect that these urban activities have on the life and livelihood of the Nation.

Fourteen "emerging problems" are also summarized in the foreword. These concern: (1) Inequalities of income and wealth; (2) lack of articulation among the industries within an urban community; (3) rapid obsolescence of physical plan and plant; (4) disruption caused by competing forms of transportation; (5) uncontrolled subdivision and speculative practices; (6) urban housing; (7) public health; (8) ethnic heterogeneity; (9) education; (10) juvenile delinquency, organized crime, and rackets; (11) public finance; (12) adjustment of the traditional scope of urban powers; (13) overlapping medley of independent governmental units; and (14) systematic evasions of civil-service laws, irresponsible political leadership, and official tolerance

of administrative practices that are discriminatory or questionable.

Next follow, in the foreword, eleven major recommendations of the Urbanism Committee. These relate to (1) further efforts toward raising the level of family income and increasing economic security; (2) continuation on the part of the federal government in its policy of cooperation with and assistance to the social-service programs of urban communities; (3) the setting up of a section for urban research in some suitable federal agency; (4) consideration of legislation primarily for periods of economic distress creating a federal agency authorized to make loans and grants under adequate legislative safeguards to local governments for purposes of public-works construction; (5) establishment of a permanent public-works authority; (6) adoption of a national policy for rehousing the low-income groups at acceptable minimum standards; (7) certain activities of a permanent national planning board for the benefit of urban communities; (8) an inquiry of conflicting fiscal policies and taxation in local, state, and federal governments; (9) legislation relating to interstate compacts between communities in a metropolitan area; (10) enactment by the federal government of additional uniform criminal laws and interstate compacts relating to health, sanitation, regulation, planning, and other governmental functions; and (11) devices by which the competence and prestige of the urban public service can be raised.

Finally, there are summarized five possible accomplishments, as follows: (1) Improvement of the standards of urban life; (2) elimination of "urban blight and erosion;" (3) better knowledge about conditions would be achieved by means of a nationally organized system of urban reporting and research; (4) better planned urban industrial location and development; and (5) national-urban preparedness to meet insecurity and unemployment.

Although the foregoing brief summary is fragmentary and needs clarification, these faults can be cured by a reading of the report. The problem concerns engineers as citizens primarily; and, because of the increasing participation of engineers in civic affairs, the report should be of interest to them.

Back Up the E.C.P.D.

DISCUSSION at the 1937 Annual Meeting of the Engineers' Council for Professional Development, as briefly reported on page 883 of this issue, uncovered divergent opinions as to the rate of progress being made by the Council's program. Some persons expressed gratification and others disappointment, and in attempting to understand these apparently conflicting views it is necessary to consider, in addition to the youth of the movement, other reasons which are inherent in the functions of the Council.

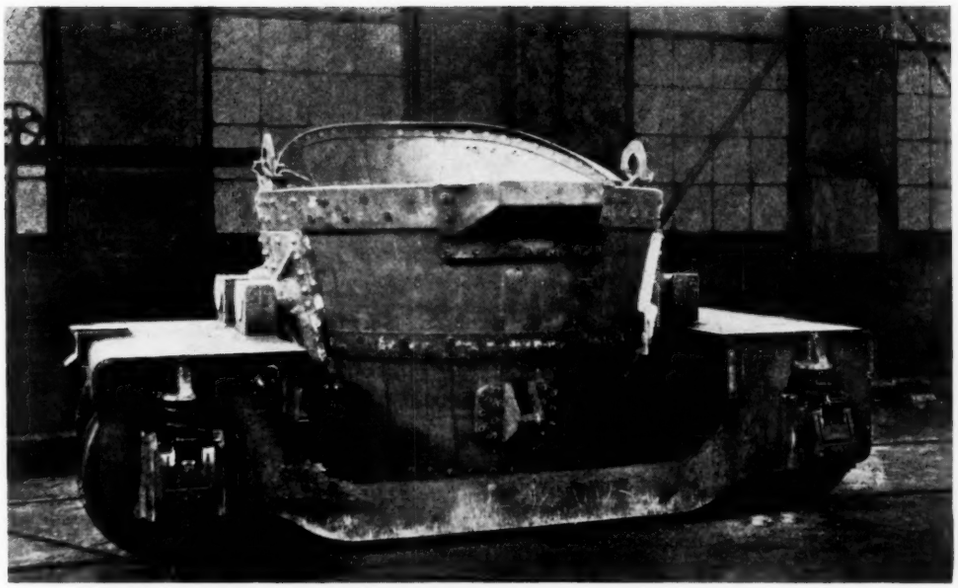
E.C.P.D. is a policy-forming and advisory body. While it has a few operational functions, such as its accrediting program and endeavors to provide aids to young engineers, the mechanisms by which its general program of raising the status of the profession is to be advanced are in the hands of constituent bodies.

The responsibility for actually putting into effect policies approved by the Council rests squarely on engineering societies and groups of engineers within those societies. For example, it is not the function of E.C.P.D. to set itself up as an active agency for counseling students who are considering engineering as a career but to make available methods by which persons and groups interested in such activities may perform their work with better effect and greater intelligence. Similarly, although methods of professional training of college graduates taking the first steps in active engineering practice are being studied and developed by the Council, their application is an obligation of groups of local engineers, aided and encouraged by national engineering societies and not of the Council, except in so far as the Council's advice and assistance are requested.

At this stage, therefore, the most urgent need appears to be to inform engineering societies and their members of what E.C.P.D. is and what it is trying to accomplish. This requires a close contact between the Council and its constituent bodies for the purpose of putting to effective use the aids, suggestions, and mechanisms developed by the Council or considered by them as being effective, and of securing that degree of enthusiastic support for the objectives of the program that will place these aids, suggestions, and mechanisms into operation. Hence, as one observer views the present situation, publicity is E.C.P.D.'s great need at the moment.

It may well be that, in a sense, E.C.P.D. is getting ahead of the procession and that disappointment in its progress toward its objectives arises from the fact that the E.C.P.D. itself is not the agency through which the operation of the program is to be conducted, as some persons erroneously assume. When the advisory and policy-forming function of E.C.P.D. is more generally understood, as well as the objectives toward which its program is directed, engineers individually and as local and professional-society groups will realize that it is up to them to put the program into effect. Conspicuous examples of active participation in the program can be found in several engineering societies and communities. When other communities are stimulated to act, they will find E.C.P.D. able and willing to be as helpful as a source of information on procedure and as a clearing house of ideas, aids, and suggestions, as its functions permit.

It takes time, repetition, and emphasis to develop a widespread understanding of a movement like the E.C.P.D. The E.C.P.D. has shown a fine quality of leadership in developing its program, but it needs to be backed up by individuals and organization that will put the program into effect in every community where it can be applied. As fast as a greater number of engineers understand the program they will discover ways of putting it into effect and thus back up the Engineers' Council for Professional Development.



AN EXAMPLE OF OXYACETYLENE SHAPE-CUTTING MACHINE'S WORK
(All the body parts of this transfer car for molten metal, including the side frames, were cut to an exact fit by the machine and no machining was required before they were assembled by welding.)

Recent DEVELOPMENTS *in* FUSION WELDING

By C. W. OBERT

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RESEARCH and scientific study have done much in recent years to advance the various welding processes. This has involved investigations of both the welding processes and the characteristics of the materials being joined or treated. Whereas in the early days of the welding art basic qualities of the material were often thought to be at fault, recent work has shown that either the welding process or the material could adversely affect the result. Improvements in welding processes have undoubtedly been more rapid than those in the materials, but now considerable is known about the characteristics of most of the weldable materials. In fact the importance of this phase of the subject has been recognized by the American Society for Testing Materials which has issued Standard Specifications A-151-35 covering the carbon steels that are known to be capable of being fusion welded satisfactorily. These general specifications exclude Bessemer steel material and all steel having a carbon content in excess of 0.35 per cent.

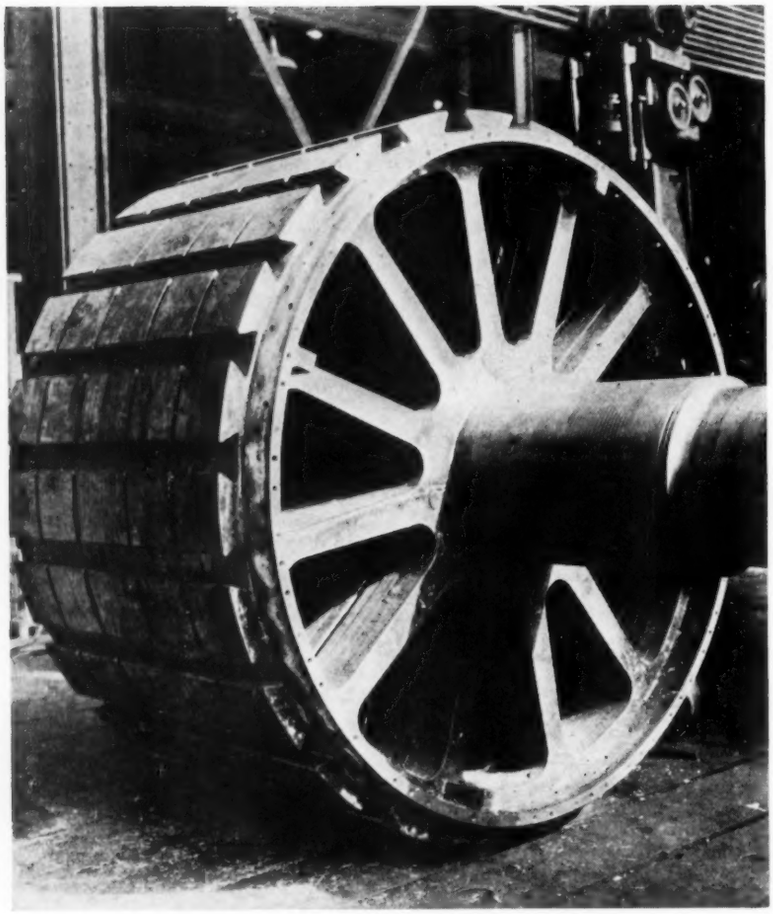
The article on Welding of Metals in the edition of the Metals Handbook that was published in 1936 by the American Society for Metals has classified the various metals with regard to their welding characteristics, including wrought and cast iron, wrought and cast steel, low- and high-alloy steels, stainless steel, copper and copper alloys, aluminum, and nickel and nickel alloys. Under each classification the metal is treated as broadly as possible with present data available, covering applications of all principal types of welding process. Data are recorded pertaining to desirable types of filler metal for each process, fluxing requirements, need for preheating or post heat-treatment, and desired manipulation of the welding process. While it is hoped that the data submitted have proved useful, it is recognized that they are as yet incomplete. The welding industry is being combed for further data to complete the records under certain classifications and to this end the assistance of the readers is solicited.

Contributed by the Machine Shop Practice Division and presented at a meeting, Atlantic City, N. J., Oct. 19, 1937, held under the joint auspices of the Machine Shop Practice Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS and the American Welding Society.

FILLER METAL

The question of filler metal was at one time a serious consideration. At first the tendency was for welding fabricators to use any kind of wire or rod available, the assumption being that melting in the course of the welding process purified the weld metal sufficiently for the purpose. This view has, however, undergone a radical change and now definite specifications, not chemical but physical, governing the quality of the deposited weld metal are available. All chemical requirements are avoided because so many different compositions are capable of producing satisfactory welds if other features of the process application are properly manipulated. In other words, satisfactory welds cannot be obtained on the basis of chemical composition alone and demanding certain specific physical properties is now considered most effective, allowing the welding fabricator to utilize any means desired to obtain the required properties.

Tentative Specifications for Filler Metal issued last year by



THE OXYACETYLENE SHAPE-CUTTING MACHINE PRODUCED THESE IDENTICAL ROTOR SECTIONS

the American Welding Society exemplify this new idea by requiring welding rods and electrodes to be such that when deposited by any fusion-welding process in low-carbon commercial rolled plate certain tensile-test and bend-test requirements will be met. These requirements are divided into five groups as follows:

Specification no.	Tensile strength, per cent of base metal	Bend elongation, per cent
10	100	30
15	100	25
20	95	20
30	85	10
40	90	7

After approximately six years of experience with filler-metal specifications of this form in which all reference to chemical composition is avoided, satisfactory results have been obtained. With certain highly developed applications, deposited weld metal has been obtained which exceeds in quality the general average of rolled-steel plate, and all evidence points to the fact that the requirements in their present form have done much to raise the general standards of fusion welding.

WELD QUALITY

For many years checking the quality of deposited weld metal without applying some destructive tests was considered impossible. This meant cutting a test sample out of the completed weld either in the form of a full-size test specimen or in the form of a diminutive specimen removed either by trepanning or slotting for etching and microscopic examination. This form of testing, while still used to some extent, was not sufficiently convenient or representative to inspire the confidence in welding that was desired and as a result certain nondestructive tests were established including X-ray and Gamma-ray examination, magnetic analysis, and sonic or stethoscopic testing. Of these the X-ray method of examination has been given the widest use and satisfactory results are obtained in determining the condition of welds on plate thicknesses up to more than 5 in. This method of process testing has been largely responsible for rapid advances in fusion welding for boiler drums and shells and for pressure vessels of all kinds. This art has developed to a point where, with proper technique, accurate and definite photographic views of the interior of welds may be obtained. Gamma-ray testing has been used only on special applications up to date.

Magnetic analysis has been used only to a limited extent for examination of deposited weld metal. It is useful for detecting cracks at or near the surface of the weld but it cannot be expected to give a complete indication of the condition of the interior in welds of considerable depth. The stethoscopic test has been used to some extent and results obtained tend to indicate that defects in welds can be located in plates of moderate thickness.

For the great majority of welding applied to structural steel, to machine frames, and for pressure vessels of less important classifications no nondestructive testing is required. For such welding applications the custom is to provide for testing the welding operators to make sure that they are properly qualified for the work they are expected to produce. Such operator qualification is usually based on tests of sample welds made by the operator with the process that is to be actually used. A number of different testing procedures have been devised for such qualification purposes, but recently the American Welding Society has issued a set of rules for both qualification of the process and testing of the welding operator which promises to meet the needs of the industry more satisfactorily than any of the former ones.

These new rules provide for testing the established process to make sure that it is adequate to meet all requirements for strength, shock, endurance, and similar properties, whereas the test procedure for checking the welding operator is only that necessary to prove that he can properly apply the established process. With this new set of rules satisfactory results have been obtained.

STRESS RELIEVING

In the development of welded structures of all sorts warping troubles, deformations, and failures have led to the institution of numerous investigations which have proved that stresses locked up in the metal following the welding operation can be serious in character. It is generally considered impossible to avoid entirely such locked-up stresses although in the more ductile materials these shrinkage stresses are not found to be so serious in their results. In the higher-strength and less-ductile

materials it is generally considered to be desirable to subject the completed welded structure to some sort of a heat-treatment that will tend to relieve or at least minimize the intensity of the locked-up stresses.

The magnitude of locked-up stresses depends on several elements, such as number of welds, their position, and the welding technique employed. With some welding techniques these stresses can be greatly reduced. If they are not minimized in some manner results are likely to be objectionable, and to avoid this a form of heat-treatment known as "stress relieving" has been developed. This involves heating either the welded part or the entire welded assembly uniformly to a temperature between 1100 and 1200 F and holding this temperature for a period of time equivalent to one hour for each inch of thickness of the thickest part welded; the structure is then allowed to cool slowly under still-air conditions. This requirement which originated in the A.S.M.E. Boiler Construction Code has been applied with satisfactory results to all kinds and types of structure.

Where stress relieving an entire structure is impossible because of its form or size, provisions are made in most codes and specifications for stress relieving in sections. This is accomplished in the case of pressure vessels, piping, machine frames, and similar constructions by applying a furnace or other heating means locally to the region desired to be treated, heating the part covered to the temperature and under the same conditions as previously mentioned. In such cases it is generally considered desirable to heat the metal in a circular area around the welded portion for a distance of at least 12 times the thickness, the direction of heat application being away from the weld. In annular-ring welds the area to be heated should be at least six times the thickness of the metal wall measured along the pipe on either side of the weld. Under such conditions of application satisfactory results have been attained, but little experience has been obtained in application of the stress-relieving process to structural-welding work as applied in building or bridge structures.

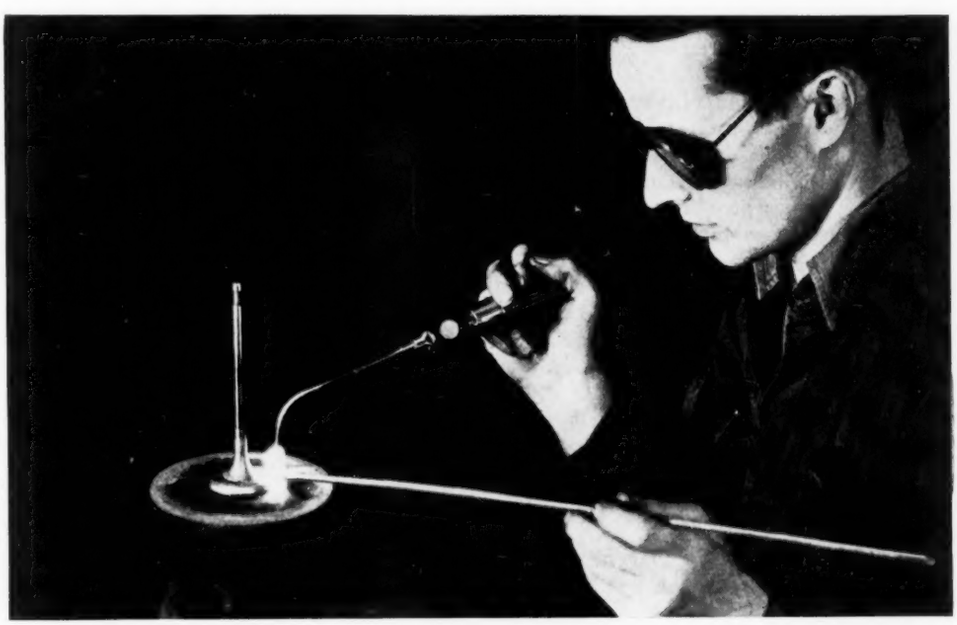
In this field of structural welding considerable research is being carried out not only to determine the actual need of stress relieving but also to devise ways of avoiding it where possible.

From what has been stated thus far in the paper it will be readily evident that the problems involved in application of fusion welding to the ordinary commercial grades of rolled and forged steel have been fairly well covered and that as a commercial fabricating process the welding art has been generally accepted in industry. When we wander outside of the range of the ordinary commercial grades of low-carbon steel and attempt to apply fusion welding to the alloy steels, cast iron, and certain of the nonferrous metals, problems of greater or less difficulty arise. In spite of the fact that much research work is underway, much work must still be done to bring this phase of the art down to a commercial basis. In the 1936 edition of the Metals Handbook the article on Welding of Metals contains a process chart and a descriptive outline that attempts to show the applicability of fusion welding to this wide range of metals, but the tabulation is conspicuous for its many gaps. These gaps are due, however, more to lack of knowledge than proved knowledge of inapplicability. This is the field where the greatest amount of investigation is needed and metallurgists can do more than any other group to solve these problems which are manifold in character because they involve in some cases the union of dissimilar metals. In fact the problem of joining dissimilar metals offers probably the greatest opportunities for investigation and development of any phase of metal fabrication.

In welding alloy steels a wide difference exists between the treatments to be accorded to high-alloy steels as compared with low alloy. In fact many of the latter have been found to be particularly well adapted for fusion-welding applications. These include the molybdenum and certain of the nickel-steel alloys. Those containing manganese, however, must be treated with care to avoid air hardening and formation of cracks. With the proper procedure and welding technique, however, strong, durable welds can be obtained in these steels.

The difficulties of welding high-alloy steels are generally increased in direct proportion to the complexity of the composition. Stainless steels have characteristic tendencies for precipitation of chromium carbide in the grain boundaries in the region adjoining the weld which causes susceptibility to intergranular corrosion which, of course, destroys the stainless characteristic. In the so-called 18–8 group of stainless steels stabilization by additions of columbium or titanium has the effect of greatly facilitating welding. In fact satisfactory procedures have been established for welding this stabilized material, as well as a series of proof tests to show the strength and inherent resistance of the weld zone against corrosion.

Satisfactory progress has been made in developing special procedures and techniques for welding cast iron over a wide range of variations in composition. Preheating is essential if the material is to be welded with filler metal closely resembling its own composition; only when a suitable nonferrous



AUTOMOTIVE VALVES LAST LONGER WHEN HARD-FACED

filler rod is used can preheating be avoided. In only a few applications can this material be welded satisfactorily without some form of heat-treatment.

Within the last few years many new compositions of alloy cast iron have come into use. For welding these much investigational work needs to be carried out. Without doubt satisfactory procedures can be established for most of these alloy compositions, but the thought is here proposed that if some investigative work is done alloy compositions might be developed that are especially suitable for fusion welding. Here is a fertile field for metallurgical work.

APPLICATIONS OF NONFERROUS WELDING

One of the biggest opportunities in the wide field of nonferrous materials lies in the application of nonferrous welding to the joining of ferrous metals. Practically all nonferrous metals are well adapted to fusion-welding applications. Some of these, such as copper, require special treatment to reduce oxides that otherwise tend to segregate at the grain boundaries adjacent to the welds. In aluminum particularly the tendency to oxidize rapidly on the surface has caused difficulties in welding applications, but suitable fluxes have been developed which readily overcome this difficulty. When the wide range of nonferrous alloys is approached, complexities and difficulties magnify rapidly. In some cases each different composition requires special consideration to secure good results. Nickel alloys are, however, well-adapted to fusion welding.

REMOVING GATES AND RISERS FROM CASTINGS WITH AN OXYACETYLENE CUTTING BLOWPIPE

The most common application of nonferrous welding to the joining of nonferrous metals is what is known as "bronze welding." This is not a true fusion-welding process, as the metal parts to be welded are not actually melted but only heated to a point where "tinning" and amalgamation with the added bronze takes place. A highly satisfactory bond for many types of work is obtained in this manner. Often, as with cast iron, the joint between the metal and the bronze filler is stronger than the base metal itself. Recent investigations into the character of this bond have revealed that adherence of bronze to the base metal is a result of three effects, tinning, alloying, and intergranular penetration. The relatively low temperature required for bronze welding is responsible for greatly increased working speeds, and the property of bronze to yield readily as it cools reduces the possibility of locked-up stresses in welded castings.

A close second in this field is the process known as surfacing or facing which involves the application of nonferrous weld deposits to wearing parts of machinery to restore them to their original form. Application of certain types of wear-resistant material renders such wearing parts actually better than when they were new. The material most commonly used for this purpose is the group of bronzes that are so commonly used for antifriction bearings. These materials are readily applied to the worn wearing surfaces by certain welding processes and the deposits can then be machined to restore the wearing surfaces to their original dimensions.

Going a step farther in this direction we come to the large and attractive field of hard facings. In this a number of special alloys have been developed which are found to be exceptionally resistant to wear and abrasion. For these applications a relatively thin layer of one of these special materials is welded onto the worn wearing surface. The several different types of these materials can be applied for a number of different uses and are classified as follows:

(1) Cheap and short-lived alloys such as low-alloy cast iron and plain carbon steel.

(2) Alloy steels principally of an iron base with additions of chromium, tungsten, manganese, silicon, and carbon.

(3) True hard-facing alloys having compositions of from 50 to 80 per cent of iron with additions of one or more of the alloying elements used in (2) and sometimes small quantities of cobalt or nickel.

(4) True hard-facing alloys consisting principally of nonferrous alloys of cobalt, chromium, and tungsten.

(5) Carbide materials which are composed mostly of tungsten-carbide particles with small percentages of ductile metals for binders.

(6) Crushed tungsten-carbide fragments made available for welding by fusing to a strip of metal or combined with other hard-facing alloys in welding rod.

This group of surfacing materials offers great promise for future development as these facings can be applied to protect the surfaces in machines that receive the greatest wear which permits utilization of cheaper material for the rest of the machine or part. The hard facing keeps the wearing parts in efficient condition much longer and not only decreases power requirements, but also avoids shutdowns.

From the outline that has been given many features of the fusion-welding art will be observed to be of prime interest to the metallurgist and are in fact inherently a part of his field.

Development of different types of filler metal would appear to depend upon the skill of the metallurgist, and above all development of base-metal modifications to render them more suitable for fusion welding is a great opportunity for the metallurgist. With the intelligent guidance of capable scientists the art of fusion welding has undoubtedly a broad and promising future.

RADIOGRAPHIC INSPECTION

Its Application to Joints in Field-Welded Pressure Piping

By H. R. ISENBURGER

PRESIDENT, ST. JOHN X-RAY SERVICE, INC., LONG ISLAND CITY, N. Y.

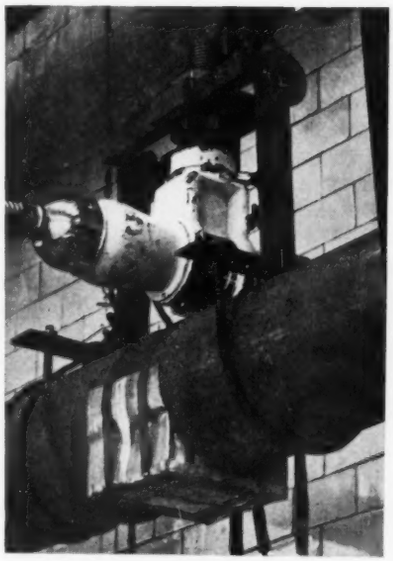


FIG. 1 TUBE AND FILM HOLDER SET UP ON A PIPE JOINT

ONE of the greatest aids to the introduction of fusion welding for important work such as boiler drums, petroleum stills, autoclaves, and the like has been the provision for nondestructive testing. While opposition to such tests was encountered at the outset, everyone will now agree that no single feature has done so much to inspire confidence in fusion-welded construction as nondestructive tests. The original criticisms of government authorities that welded joints should not be allowed because "we cannot see what is inside of them" were entirely dispelled by nondestructive testing, particularly X-ray examination of the joints. This method is the only means by which a permanent record of actual conditions inside the weld metal can be obtained. The great advantages of this fact were soon recognized by the Boiler Code Committee of The American Society of Mechanical Engineers and rules for this method of testing were incorporated in its regulations for welding unfired pressure vessels.[1]

In the author's opinion it is just as important, if not more so, to examine the seams in high-pressure piping. There has been a tendency to treat welded-pipe fabrication on much the same basis as the former class 2 pressure vessels,[2] until pressures rose to 1400, 1600, and 2000 lb per sq in. With these extreme pressures and high temperatures that have now become everyday practice, all welded pipe joints between the boiler and the turbine must meet A.S.M.E. Boiler Code requirements. Difficulties have been encountered in connection with the inspection of field welds. All headers and sections that could be shop-fabricated and shipped to the place of erection could, of course, be X-rayed in the shop. But the inspection of the field welds was a problem that many, even until recently, thought could not be solved in practice.[3]

When we were first confronted with this problem we saw clearly that we could not use the same type of equipment which was commonly employed for examining welded seams in boiler drums. This equipment was too bulky and the tubes were unsuited to the rough treatment anticipated for field conditions. Usually the plant is being constructed when X-ray work has to be performed. This requires the utmost attention from the operator who must be able to rely on his tools. Fortunately, we are now able to import specially designed X-ray tubes that had been used abroad for industrial radiography but could not be brought to this country until the expiration of the Coolidge patent a few years ago. These tubes are completely ray- and shockproof, air-insulated, and water-cooled. (See Fig. 1.) The sharply inclined target is equipped with a so-called line-focus that assures the best possible details.[4] The other feature of this tube is the incorporation of an electron filter or grid system eliminating some of the most undesirable radiation characteristics.

Use of a grid in line-focus tubes operating on pulsating-potential circuits[5] enables the same X-ray output to be secured as is obtainable on constant potential. In tubes with grids, X-rays are generated near the crest of the tension curve, and, therefore, not only is the X-ray output almost as large as on constant potential but also the half-value layer is larger than that obtained with tubes of conventional design operated on pulsating potential. Fig. 2 illustrates the principle of grid action. A small transformer and a condenser are used to obtain a pulsating potential which, with respect to the cathode of the X-ray tube, is positive only when the tension across the tube t_h is at its maximum. As long as the grid potential e_g is negative with respect to the cathode, electrons cannot pass from the cathode to the anode since the negatively charged potential repels them. When the grid is positive with respect to the cathode, it not only will allow passage of electrons but also will favor them. Thus, a large passage of tube current i occurs during this period. Since tube current flows when the high tension is near or at its maximum value, a high X-ray output with a high half-value layer is produced. The practical advantage

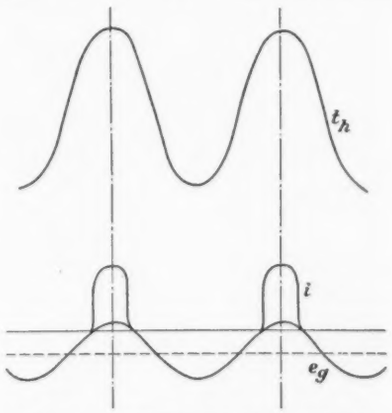


FIG. 2 PRINCIPLE OF GRID ACTION (In this diagram e_g denotes the grid potential; i, the tube current; and t_h, the tension across the tube.)

[1] "Rules for Construction of Unfired Pressure Vessels," par. U-68, 1931.

[2] "Rules for Construction of Unfired Pressure Vessels," par. U-69, 1931.

[3] "Standards for Welding Quality and Methods of Inspection of Fusion-Welded Power Piping," by W. D. Halsey, *Welding Engineer*, vol. 21, December, 1936, pp. 38–42.

[4] "X-Rays and X-Ray Inspection in Piping," by H. R. Isenburger, *Heating, Piping, and Air Conditioning*, vol. 1, June, 1929, pp. 115–120.

[5] "Industrial Radiography," by Ancel St. John and H. R. Isenburger, John Wiley & Son, Inc., New York, N. Y., 1934, pp. 59–69.

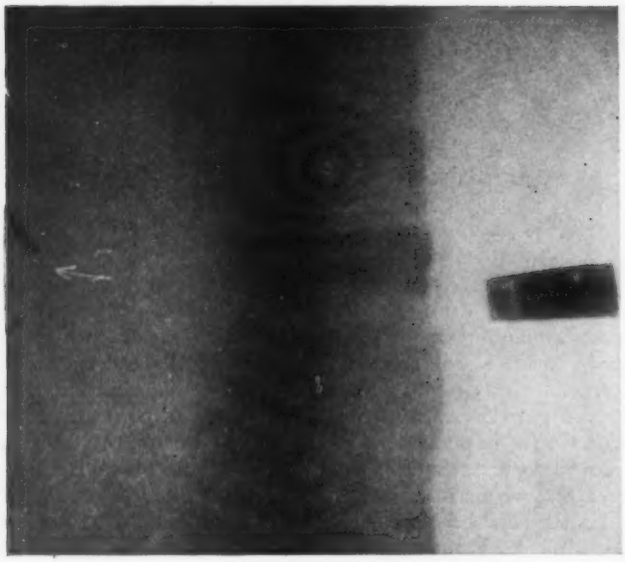


FIG. 3 EXOGRAPH (POSITIVE) OF 12-IN. PIPE JOINT WITH 2-IN. PENETRAMETER

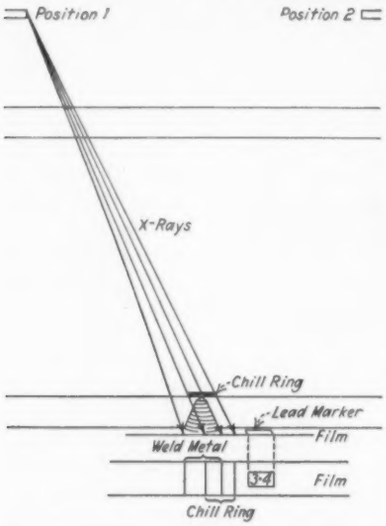


FIG. 4 (LEFT) DIAGRAM OF EXPOSURE ARRANGEMENT

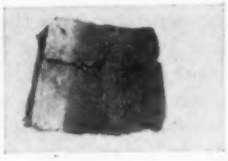


FIG. 8 PHOTOGRAPH OF A CHIP THAT WAS CUT FROM THE CRACK SHOWN IN FIG. 5

of this is the fact that only 200 kv is required instead of 300 kv with the conventional equipment for the same exposure conditions. Besides, elimination of practically all long-wave radiation prevents scattered radiation and no filtering diaphragm is necessary in front of the film.

TECHNIQUE EMPLOYED

One look at Fig. 1 will show the great advantage of these features. When X-raying welded joints in piping we have the tube on one side and the film on the other side of the pipe. Both walls thus have to be penetrated by the rays. Only the portion of the weld near the film is utilized in the interpretation. Depending upon the diameter of the pipe and the thickness of its wall the steel toward the tube is likely to scatter so much that it would obscure the entire image of the welded seam. This is not the case when using line-focus tubes. Fig. 3, an exograph through a 12-in. pipe, demonstrates this fact. The total thickness of metal to be penetrated by the rays through the center of the weld is about 3 in. A penetrame-

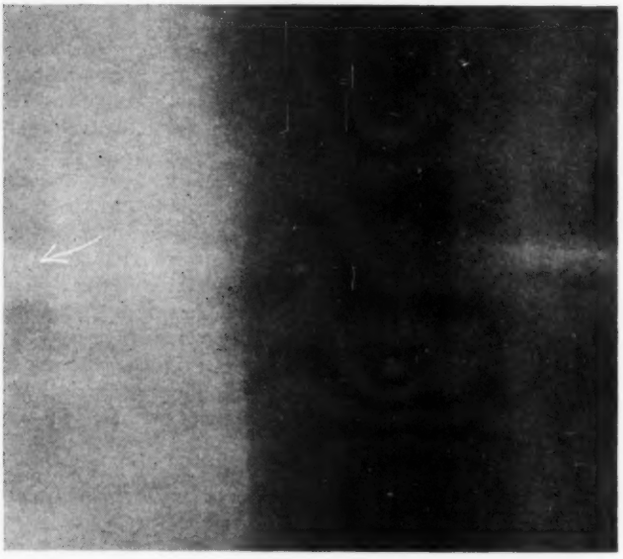


FIG. 6 GAMMAGRAPH (POSITIVE) THROUGH A 2-IN. WELD WITH 2-IN. PENETRAMETER

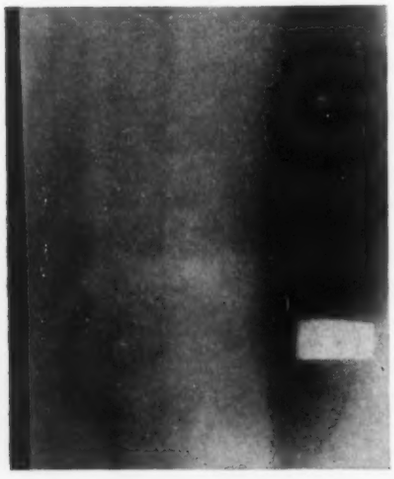


FIG. 5 THIS EXOGRAPH SHOWS LACK OF FUSION BETWEEN 3 AND 4 IN. ON LEFT SIDE OF SCARF NEAR BOTTOM OF WELD

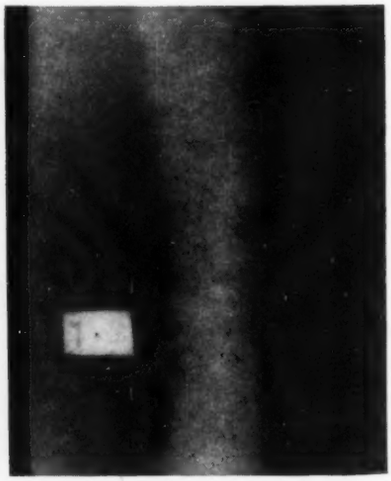


FIG. 7 TYPICAL PAIR OF EXOGRAPHS OF A WELD SHOWING THREE HOLES IN THE CHILL RING WITH CRACKS INDICATING LACK OF PENETRATION

ter of the type required by the Boiler Code[6] for plate stock up to 2 in. was placed between the pipe and the film. The last three holes are noticeable in the negative, the smallest gage showing was 0.02 in. thick which is less than 1 per cent of the total metal thickness. This penetrameter was not radiographed through the metal as it should have been, but it is sufficient for our purpose to prove that practically all scattering has been eliminated.

The X-ray technique employed does not only involve the penetration of both walls of the pipe but also features another fact of great importance which differs from the technique ordinarily employed in weld examination. During the exposure the central beam is directed approximately parallel to the scarf of the weld as originally suggested by Dr. Ancel St. John almost 20 years ago.[7] This requires the inspection of each section of the weld from two different positions as illustrated in Fig. 4. In that way we are able to detect any defects which are alongside the scarf and, as we shall see later on, can thus find the most minute cracks (Fig. 5). A 12-in. pipe joint is thus covered by six pairs of exposures, each lasting 1 min. Positioning of the tube has been greatly simplified by a rig that can be clamped around the pipe (Fig. 1). The number of exposures necessary to cover a joint depends, of course, upon the diameter of the pipe as well as the wall thickness. Where the latter exceeds $1^1/_2$ in., we prefer to use radium since the strain on the X-ray tube would be too great for the exposures required to penetrate approximately $3^1/_2$ in. of steel.

Whenever possible the radium capsule is placed in the center of the joint inside the pipe. The films are wrapped around the outside and in a few hours of exposure the entire weld can be radiographed. However, a marked difference exists between gammagraphs and exographs of approximately the same thickness of steel. The appearance of the former (Fig. 6) is that of an X-ray picture obtained in too short an exposure time and with too high a voltage. Thus no fine details of the interior conditions of the weld metal are recorded in the gammagraph. A comparison of Figs. 3 and 6 will make this point clear. Fig. 3 is an exograph through approximately 3 in. of steel whereas the gammagraph, Fig. 6, shows a weld in 2-in. plate stock which probably is $2^3/_8$ in. thick through the center of the weld. In both cases the 2-in. penetrameter was placed near the film, thus recording the sensitivity of the respective methods to surface marks only. In the gammagraph the second hole is noticeable over the 2-in. wall thickness whereas the third hole can be recognized in the exograph over a much greater metal thickness, probably $2^3/_4$ in. of steel. Our experience with radium for this type of work has again strengthened our belief that this material should only be used whenever X-rays cannot be applied and when the importance of a sound joint justifies the handling of radium. The best we can expect to detect are large gas and slag inclusions such as one seldom finds with present-day welding technique and care. Some characteristic conditions encountered in field-welded pipe joints are shown in the exographs included in this article.

A typical pair of exposures in the same section of a seam is illustrated in Fig. 7, the exographs being arranged to correspond with the side of the scarf X-rayed in each case. The lightest area through the seam indicates the chill ring inside the pipe. When interpreting exographs, original negatives must be consulted, since prints made under the most careful control will not show as much contrast and details as the original. This is so much more important since we are principally concerned with the detection of small defects. Fig. 5 is an exograph showing lack of fusion extending between 3 and 4 in. on the left side of the scarf near the bottom of the weld, a cross section of which is shown in Fig. 4. We determined the exact location of the defect from the negative and by chipping it was found as indicated. Although this defect was nothing but a fine hairline crack, it was detected in the exograph. One of the chips was photographed and is shown in Fig. 8. We have discovered this important type of defect frequently without difficulty although others have reported differently.[8] In some instances this lack of fusion is accompanied by slag inclusions, as depicted in exograph Fig. 9. A photograph of a chip from this region is reproduced in Fig. 10. When examining the weld in a 24-in. joint an adjacent seam was accidentally caught on the same film. This other weld was made in the fabricating shop and was not supposed to be X-rayed in the field. Both welds appear in Fig. 11. The one identified by a lead

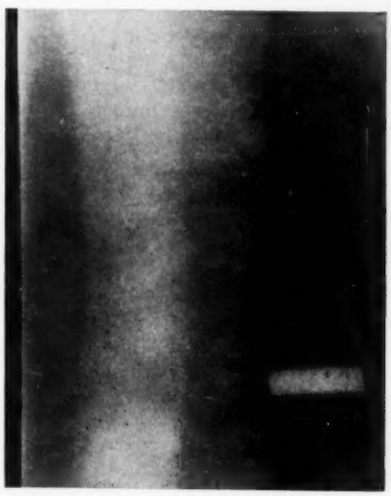


FIG. 9 SLAG INCLUSION WITH LACK OF FUSION EXTENDING APPROXIMATELY 3 IN. ON BOTH SIDES OF THE WELD AT APPROXIMATELY $^1/_4$ IN. BELOW THE SURFACE

FIG. 10 CHIP FROM THE WELD SHOWN IN FIG. 9

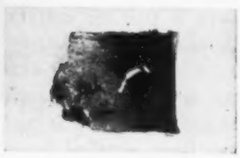


FIG. 12 CHIP FROM DEFECTIVE WELD SHOWN IN FIG. 11

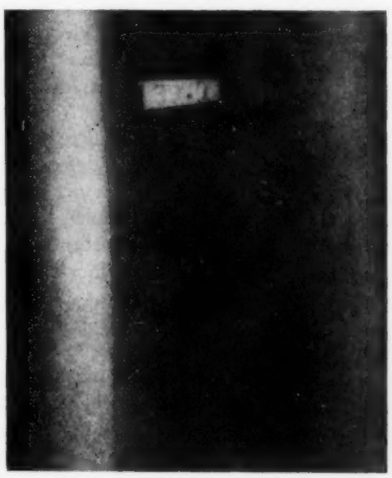


FIG. 11 EXOGRAPH OF TWO WELDS, ONE SOUND AND THE OTHER DEFECTIVE

(The weld at the left was made in the field and is apparently sound. The other weld, which was made in the shop, is of the double-V type and shows a continuous slag inclusion with a lack of fusion at the roots of the V's.)

[6] Fig. U-12, "Revised Addenda to Rules for Construction of Unfired Pressure Vessels," 1937, p. 175.

[7] "Industrial Radiography," by Ancel St. John and H. R. Isenburger, John Wiley & Son, Inc., New York, N. Y., 1934, p. 134, figs. 45*a* and 45*b*.

[8] "Some Limitations of X-Ray Inspection of Welds," by A. S. Douglass, *Journal of the American Welding Society*, vol. 13, February 1934, pp. 15–16.

FIG. 13 THE X-RAY UNIT IN A TIGHT PLACE

marker is the field weld and is evidently perfectly sound. The other seam is a double-V-weld and shows continuous slag inclusion with lack of fusion at the roots of the V's. Fig. 12 shows this in a typical chip from this weld. This weld was not radiographed before the pipe left the factory although this particular manufacturer is equipped with X-ray facilities. Due to this discovery the shop weld was repaired in the field and reexamined.

With some experience in reading the two negatives for each section of weld, we can determine accurately the location of the defects within the metal. This is more difficult when dealing with cracks like those shown in Fig. 5 than when we have a pair of exographs available as in Fig. 7. In these exographs the change of position and widening of the defects indicates their extent and form. In this case the defects are in and near the chill ring and the exographs clearly indicate that there is no penetration at the root of the weld, a condition verified by subsequent chipping for repairs.

SERVICE REQUIREMENTS DETERMINE ALLOWABLE WELD DEFECT

As usually occurs when reproducing these exographs most of the details have been lost. On the other hand, the demonstration of nothing but defective welds may create the feeling that practically each joint is defective. This, however, is not the case. On one job less than 10 per cent of the joints required repairing. In another instance 7 out of the first 11 joints had to be repaired. After this the welders learned how to make sound joints and repair work was seldom necessary. Naturally, the type of defects which can be tolerated in a joint depends upon the service requirements for that particular pipe line. Thus many defects that would be permissible in the 200-lb bleed line, for instance, cannot be tolerated in the main steam and boiler-feed lines that carry high-pressure and high-temperature live steam. No actual standards are, or can be, established. On this point the X-ray expert has to cooperate with the welding engineers and the inspector. While the radiologist points out the interior conditions of the joint, the engineers must decide whether these conditions are objectionable or not. The ideal situation would be radiographic inspection as a means of proving the soundness of the welds rather than to detect defects. One of the most important factors in favor of this nondestructive test is the psychological effect upon the welder. This work depends so much on the human element that constant supervision of the welder is necessary. An interesting fact is that the joints which were made under the most difficult circumstances showed up better than easier ones on one particular job. As a matter of fact, the simplest joint required the most repair work.

Of course, to complete a 12-in. pipe joint, for instance, in one continuous operation is by no means an easy job. The wall thickness of this pipe is about $1^1/_4$ in. and the time required for the welding is about 12 hr. After the seam has been completed it is stress relieved for about 1 hr. Radiographic inspection is made after the pipe has cooled off. The results thus obtained were most satisfactory to the company for whom this work was done. As far as the cost for the X-ray inspection is concerned, this is reasonable and well worth while. The superintendent of one of the power plants stated that the detection of only one faulty joint would pay for the expense of X-raying all the pipe joints. Speed of X-ray inspection is just twice as fast as that of welding. Most time is consumed in moving the equipment about and setting it up for the inspection. Depending upon local facilities, we have examined as many as two 12-in. joints or five 8-in. joints in an 8-hr day. Besides the X-ray technician we have an assistant and a rigger in our crew.

DIFFICULTIES ENCOUNTERED IN FIELD INSPECTIONS

The following photographs will indicate some of the difficulties encountered in the field and how they are overcome. Our portable X-ray unit is mounted on a trailer chassis and can be moved from place to place by a small car since its weight is slightly under 3000 lb. The cover can be set up on one side and used as a field darkroom when no other facilities are available. We prefer to have a larger darkroom but it can be roughly assembled and equipped with only the most necessary things. Fig. 13 shows the unit in a tight place. The X-ray tube can be seen in the foreground set up on a joint. The advantage of 30-ft cables will be clear when we look at Fig. 14. Incidentally, the platform, on which the machine is standing, is about 30 ft above the floor. To build such a platform, however, is not always possible and in some such cases chain blocks had to be substituted. Considering the delicate equipment, the accuracy with which tube and film holder must be aligned, and the noise and dirt in a boilerhouse under construction, radiographic work is by no means an easy task. In view of the difficulties, the excellent results thus far achieved are so much the more gratifying.

With proper technique and interpretation X-ray inspection again blazes the trail for important welding work. The facts presented in this article cannot leave any doubt that radiographic examination of field-welded joints in pressure piping is not only desirable but should be made mandatory. X-rays of all nondestructive tests offer the only means to prove beyond any doubt the soundness of the material. Anyone who believes that he can insure sound joints without such visible proof is blinding himself and others to the indisputable fact that seeing is believing.

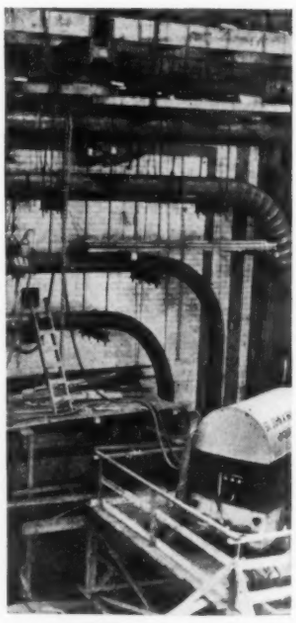


FIG. 14 ANOTHER DIFFICULT SITUATION

(The platform on which the machine is resting is carrying the high voltage and water cooling for the tube 30 ft above the floor. In cases like this, the long cables prove of great advantage.)

SURFACE QUALITY

A Review of "Technische Oberflächenkunde" by G. Schmaltz

PREPARED BY E. J. ABBOTT AND EDGAR GOLDSCHMIDT

PHYSICISTS RESEARCH COMPANY, ANN ARBOR, MICH.

SURFACE characteristics are important in many fields and have occupied the attention of many investigators. This 300-page book represents a pioneer attempt to bring all of this material together and to correlate various aspects of this new field. Considerable original work is described, and in addition, an inclusive survey of numerous references is given. These include both investigations that would normally be classed as surface studies and also those in which surface properties were incidental but throw light upon this subject. Specific reference is given to 1331 papers, and in each case pertinent ideas are treated in the text with a critical evaluation. Promising openings for additional work are indicated in many places.

Topics are included which are of interest to production men, designers, research workers, and those interested in the development of machine tools and processes. A most useful part of the book is the most excellent table of contents, which uses a decimal classification to arrange the material and to indicate the relations of the different topics. Each item is identified as to its relative interest for the four groups of readers previously listed. This table of contents represents the most complete available compilation of subject matter in this field and is valuable for use as a reference concerning concepts, extent of field, previous work, methods, and means.

Obviously, material of such wide variety of subject matter is not easily condensed. In this review we can only outline the more important and typical items. The interested reader is respectfully referred to the book itself for concise and detailed information.

The primary concept of surface as treated in this book is not purely geometric. Instead, the surfaces are represented as they really are; namely, thin bodily structures of different form and various properties. These properties involve not only geometry in three dimensions, but also crystal structure, metallurgy, and atomic characteristics of the surface layers and of others close to the surface.

SURFACE FORM OF MACHINE PARTS

Certain characteristics of surfaces are conveniently observed full scale by visual observation, while others are more minute and are best studied under magnification. For convenience, the former are classified as macrogeometric and the latter as microgeometric characteristics. The regions overlap, and after some discussion of methods of definition, the author suggests as a practical criterion, that dimensions in areas smaller than 1 sq mm be classed as microgeometric, while larger dimensions are macrogeometric. The lower limit of microgeometric dimensions occurs at about the separations of the atoms of the material. These are of the order of 0.005 microinch (5×10^{-9} in.).

Distinction is also made between fine irregularities called "roughness" and longer irregularities called "unevenness" or "waviness." Fig. 7/1 illustrates these two types of irregularity which may exist either separately or together. The following list gives familiar examples for cylindrical holes:

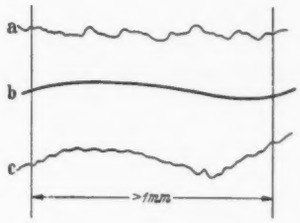


FIG. 7/1 EXAMPLES OF DIFFERENT SURFACES

(These are (*a*) rough, even; (*b*) smooth, uneven; and (*c*) rough, uneven.)

Process	Result
Ordinary boring	Wavy or uneven, rough
Reaming	Almost even, rough
Bored and dressed by hand	Almost even, smooth
Bored and honed	Almost even, almost smooth
Bored and ground	Even, smooth
"Balled" (press finish)	Uneven, very smooth
Finest boring	Very even, very smooth
Fine boring and lapping	Very even, very smooth

Since wear, friction, fatigue life, heat transfer, corrosion, optical properties, and the like, are greatly dependent on the fine structure of the surface, the designer must specify the quality to control the operation of the part during its life. Such specifications must consider both the necessity for given surface characteristics and the economics of shop production.

ROUGHNESS CLASSIFICATION OF ENGINEERING MATERIALS

(1) Very rough surfaces, such as wood, cement, mortar, brick, leather, conveyor belts, rough-cast machined parts, and similar materials. The irregularities of these surfaces are generally greater than 1 mm (0.040 in.) and usually above 2 mm (0.080 in.). They are usually so extensive that the concept of microgeometry does not apply.

(2) Rough-machining operations in which the furrows are clearly visible and easily felt. The depths of the machining furrows or other irregularities lie between 0.2 and 2 mm (0.008 to 0.080 in.).

(3) Dressed surfaces in which the machining furrows are still visible by eye and lie between 0.05 and 0.2 mm (0.002 and 0.008 in.).

(4) Finely dressed surfaces in which the grooves just fail to be clearly distinguishable by eye. These dimensions lie between 5 and 10 microns (0.0002 to 0.0004 in. or 200 to 400 microinches).

(5) Finely ground surfaces in which the average roughness lies between 5 and 10 microns (0.0002 to 0.0004 in. or 200 to 400 microinches).

(6) Finely ground and finely turned and similar surfaces which have a shiny appearance and whose irregularities lie between about 0.5 and 5 microns (0.00002 and 0.0002 in. or 20 to 200 microinches).

A review of a book entitled "Technische Oberflächenkunde" (Technical Fundamentals of Surfaces), by Gustav Schmaltz, published by Julius Springer, Berlin, 1936, 286 pp. The author is a member of Schmaltz Bros., machine builders located at Offenbach am Main, Germany. He is also an honorary professor at the Technical Institute at Hanover, Germany, and has received the degrees of Eng.D. and Honorary M.D.

(7) Lapped and polished surfaces with deviations less than 1 micron (0.00004 in. or 40 microinches). Observation with a dark-field microscope shows few scratches, the finest of which have a depth of about 0.05 micron (0.000002 in. or 2 microinches).

(8) Highest quality polished surfaces. Even in the dark-field microscope, no machine scratches are visible.

The finest irregularities in group 6 are of the order of 0.5 micron (0.00002 in. or 20 microinches), and measurements below these values become increasingly difficult.

To aid in visualizing the range of the dimensions of surface irregularities, Table 11/1 lists a number of common and technical dimensions.

Physics of Boundary Surfaces. Evidence has been obtained that on fine surfaces, molecular movements of the material produce measurable changes in the surface itself. Fig. 13/1 shows measurements of the variations in the radius of curvature of a glass sphere around 13 deg of its periphery at different times. Examples are also given of the influence of crystal structure on the dimensions and characteristics of surface layers.

The surface of a body is conceived as a layer of definite thickness which separates the undisturbed inner portion from the surrounding atmosphere or adjacent body. In turn, this surface layer consists of two parts, an inner and an outer sheath. The former consists of several layers of atoms which experience a small surface tension, approximately 0.001 lb per sq in., due to the fact that the material is on only one side. A certain quantity of surface energy is therefore stored in this sheath by this distortion.

The outer boundary sheath is about 2 atom distances thick and has "free binding forces" that attract and hold foreign particles such as air, moisture, gases, hydrocarbons, oil, and the like. These may build up to a thickness of between 10 and 20 molecule layers and are important from the standpoint of corrosion, friction, lubrication, and similar properties.

TABLE 11/1 COMPARISON OF DEGREES OF ROUGHNESS WITH OTHER VALUES

TYPE OF PROCESS	
Roughnesses of processed machine parts. (Distance between the highest and lowest points) Averages of several specimens	Planed surfaces Dressed surfaces Finely dressed surfaces Finest turned and finest bored surfaces Lapped and polished surfaces Very best polished surfaces
Tolerances in the I.S.A. system	Tolerance of a shaft o to 50 mm diameter I. T. 1 Tolerance of a shaft o to 50 mm diameter I. T. 5 Tolerance of a shaft o to 50 mm diameter I. T. 11 Tolerance of a shaft o to 50 mm diameter I. T. 15
Working accuracy of machine tools (macrogeometric)	Working accuracy of new machine tools of ordinary quality Working accuracy of machine tools of highest quality
Boundary layers of metallic surfaces	Thickness of lubricating layer in ordinary bearings Thickness of the lubricating layer on work-spindle bearings of ordinary machine tools Thickness of the lubricating layer on the work spindles of machines for finest machining Thickness of the grease layer on polished steel surfaces after ordinary cleansing Average thickness of adsorbed layer on gage blocks after careful cleaning Thickness of adsorbed gas, liquid, or grease layer on polished surfaces; cannot be removed by rubbing Thickness of a red-oxide layer (tempering color) on metals
Elements of materials	Size of structure kernels and single crystal in iron Length of a fatty acid molecule Distance of the atoms in a crystal lattice Diameter of the spherical shell of atoms Amplitude of vibration of atoms in a crystal lattice at ordinary temperatures
Other bodies for comparison	Thickness of a human hair Diameter of a red blood corpuscle Thickness of quartz or carborundum grains which do not sink in water Size of particles in a colloidal gold solution
Other lengths for comparison	Thermal expansion of an iron body of 0.4 in. for a 1-deg temperature change Extension of a steel bar, 4 in. long under a stress of 70,000 lb per sq in. Mean free path of gas molecules at average temperature Average wave length of infrared light Average wave length of visible light Average wave length of ultraviolet light Average wave length of X-rays
	Limit of the microscopically resolvable forms Limit of particles which can be observed by dark-field ultramicroscope

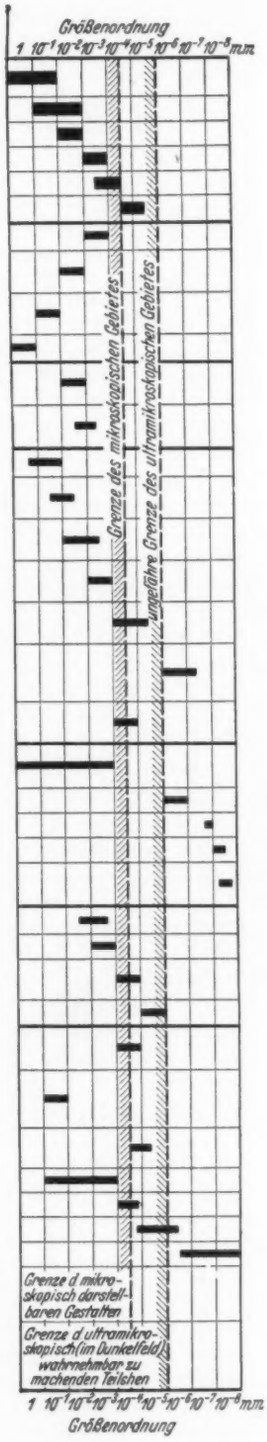

Größenordnung
1 10⁻¹ 10⁻² 10⁻³ 10⁻⁴ 10⁻⁵ 10⁻⁶ 10⁻⁷ 10⁻⁸ mm
Grenze des mikroskopischen Gebietes
Jetzige Grenze des ultramikroskopischen Gebietes
Grenze d. mikroskopisch darstellbaren Gestalten
Grenze d. ultramikroskopisch (im Dunkelfeld) wahrnehmbar zu machenden Teilchen
1 10⁻¹ 10⁻² 10⁻³ 10⁻⁴ 10⁻⁵ 10⁻⁶ 10⁻⁷ 10⁻⁸ mm
Größenordnung

Fig. 21/1 shows a photomicrograph of a section of the depression left by a Brinell test in a piece of purest iron. The inner distortions are clearly seen.[1]

METHODS OF SURFACE TESTING

The author classifies these in five groups

(1) Investigation of surfaces by the sense of touch.

[1] The reviewers suspect that this is essentially the mechanism of a "rolling" or "burnishing" process. Instead of "bending over the "peaks," as popularly explained, it is believed that the substructure is changed, and this affects subsequent wearing properties.

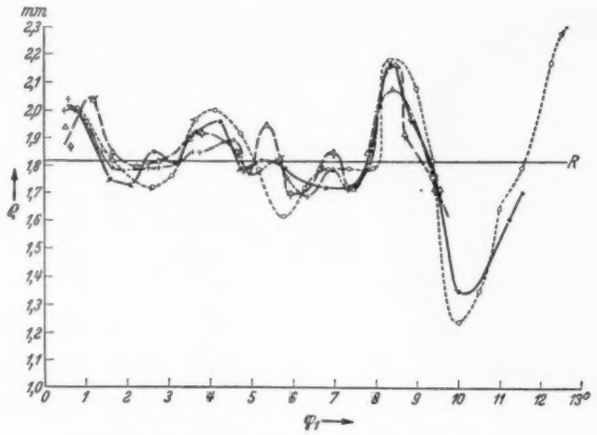


FIG. 13/1 RADII OF CURVATURE ρ OF A POLISHED GLASS SPHERE IN A REGION OF 13 DEG OF ITS SURFACE AND IN TIME INTERVALS OF 15 MIN
(Schmerwitz.)

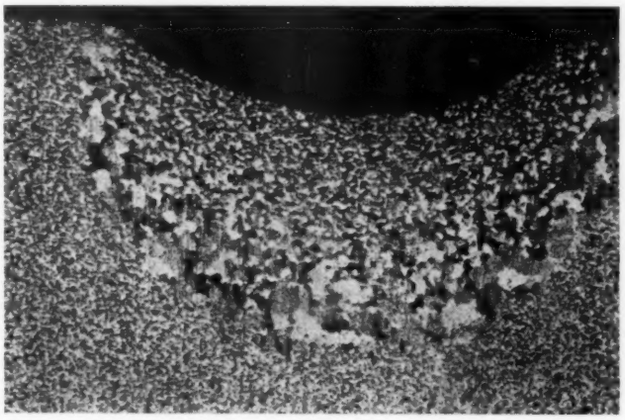


FIG. 21/1 FORMATION OF THE INNER BOUNDARY LAYER OF PURE IRON, WHICH WAS SUBJECTED TO A BRINELL (PRESSURE) TEST
[Deformation by recrystallization is made visible. Magnification 10×
(Nieberding).]

(2) Visual inspection by unaided eye or microscopic magnification.

(3) Methods for detection of individual flaws.

(4) Methods for obtaining profile or contour curves of the fine structure of surfaces. Only this group gives direct and complete information concerning the surface form.

(5) "Integral" or "mass-effect" methods that give a measure of the surface in terms of closely related factors such as friction, flow resistance, light reflection, X-rays, and electron interference. These methods give numbers which are influenced by all surface elements and therefore have the character of an average or integral value.

Tests by Sense of Touch. If the finger is held still on a surface, it is practically useless as a gage of roughness, because the nerve ends are about $^1/_{32}$ in. apart. When the fingers are drawn across a surface, the nerve ends are vibrated and are able to detect extremely small irregularities. Fig. 30/1 shows the least detectable magnitude at various speeds of trace. These range from 4 to 40 microinches (0.000004 to 0.00004 in.) in height. For ordinary surfaces with roughness spacing of about 0.005 in., the greatest sensitivity is obtained at a speed of about 1 ips. At this condition, the finger can feel irregularities that cannot be resolved by the best microscopes.

Visual and Microscopic Observation. With the unaided eye, it is possible to separate two points which form an angle of about 1 min of arc. At a distance of 10 in., this corresponds to about 0.003 in. separation. It is possible to detect the presence of scratches down to about 1/100 of this limit, although they cannot be seen clearly.

Fig. 36/1 shows a method of observing surface irregularities by the light passing under a knife-edge held against the specimen. This is useful for rough surfaces, but on fine ones the light diffraction is so great that observations are not reliable. (See Fig. 37/1.)

Visual and photographic examination of surfaces both with and without the aid of the microscope, is an important means for surface determinations, and 15 pages are devoted to the description of various techniques. Two of the most important factors are (*a*) method if illumination and (*b*) amount of magnification used. Illustrations are given of a number of different methods of illumination and the advantages of each. Individual views of Figs. 40 and 46 illustrate differences in the appearance of the same surfaces under different illumination.

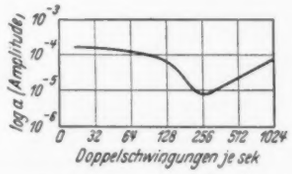


FIG. 30/1 DEPENDENCE OF SENSITIVITY OF TOUCH ON THE FREQUENCY
(Amplitude threshold. Knudsen.)

FIG. 36/1 LIGHT-SLIT METHOD WITH KNIFE-EDGE

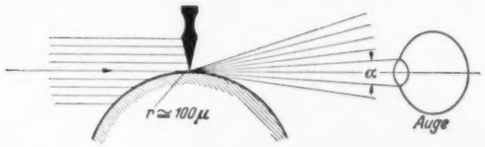


FIG. 37/1 LIGHT-SLIT METHOD WITH KNIFE-EDGE SHOWING DIFFRACTION

The so-called "dark-field" illumination is particularly useful for very smooth surfaces. Illumination with parallel light and use of low magnification are helpful in observing long waves that are astonishingly difficult to observe by ordinary means. While one can obtain some idea of profile dimensions of the surface by varying the illumination, these methods are essentially studies of the plan view of the surface, and only qualitative information is obtained for the profile.

As is well known, the resolving power of the microscope is limited by the wave length of light. Under ordinary conditions, at highest magnification, one can just distinguish two points which are from 20 to 40 microinches apart. It is therefore impossible to form clear images of objects smaller than this. For many surfaces, heights of the irregularities are less than this limit.

By using ultraviolet or other short-wave light, somewhat higher resolving power can be obtained. The electron micro-

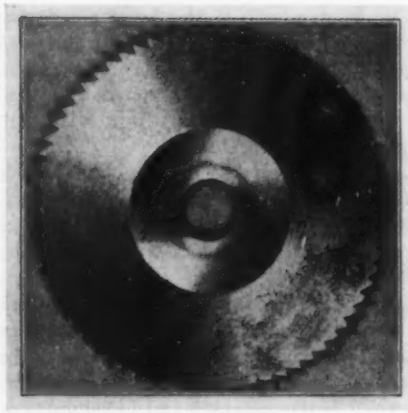


FIG. 40/1 CIRCULAR-SAW BLADE
(Photograph with two opaline light bulbs.)

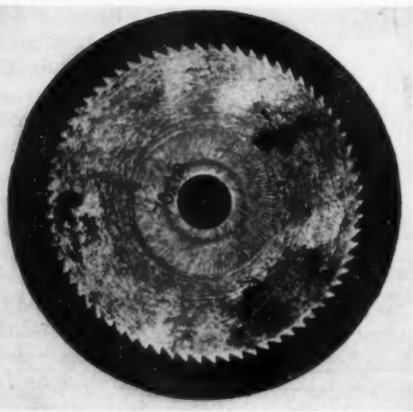


FIG. 40/2 CIRCULAR-SAW BLADE
(Illuminated with ring illumination. Reduced 0.6×.)

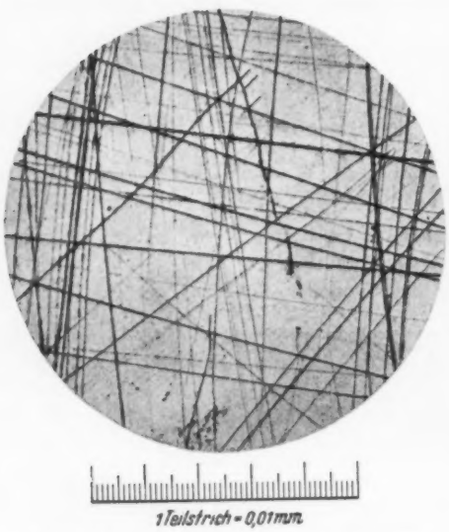


FIG. 46/1 POLISHED STEEL ILLUMINATED WITH EPICONDENSER
(Light-field illumination. Magnification 71×.)

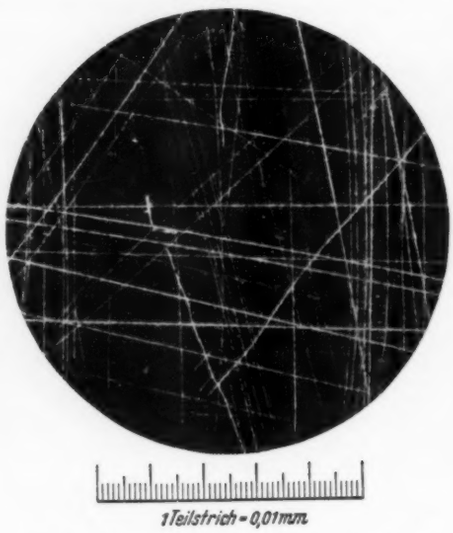


FIG. 46/2 POLISHED STEEL ILLUMINATED WITH EPICONDENSER
(Dark-field illumination. Magnification 71×.)

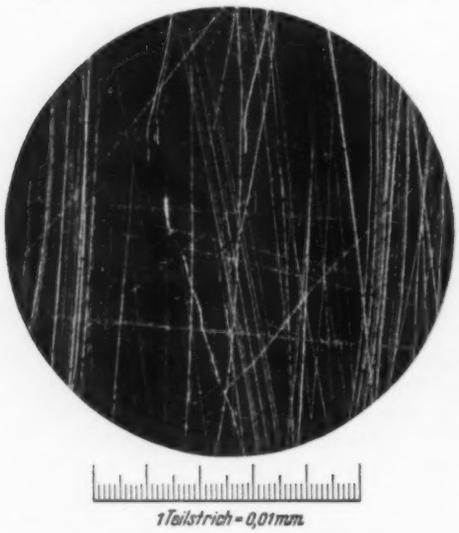


FIG. 46/3 POLISHED STEEL ILLUMINATED WITH EPICONDENSER FROM THE RIGHT
(Magnification 71×. Influence of the azimuth.)

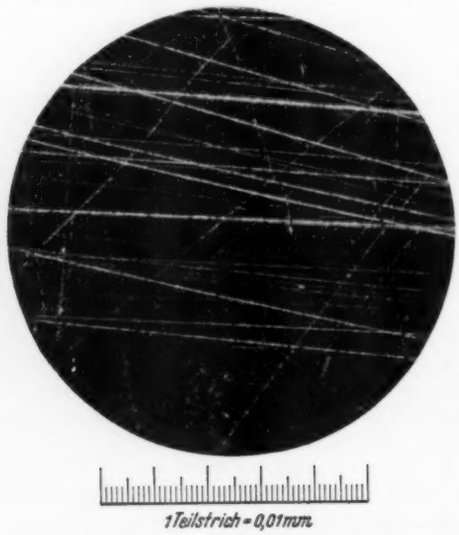


FIG. 46/4 POLISHED STEEL ILLUMINATED WITH EPICONDENSER FROM ABOVE
(Magnification 71×. Influence of the azimuth.)

scope that uses electron beams instead of light waves is another possibility. These methods involve many technical difficulties, and at present are essentially laboratory methods.

Magnetic Tests. Flaws in magnetic materials can be detected by so-called "powder methods" and by magnetic means. Many variations of these methods have been devised.

Section Methods. To determine the vertical dimensions of surface irregularities, it is necessary to study them either in horizontal or vertical sections. In certain cases, light-interference curves can be interpreted in terms of surface contour, and these methods are discussed. By marking the surface with color and rubbing against a flat plate, or by removing material in steps, data can also be obtained on surface contours.

The Tracer Method. Profile curves of surfaces can be obtained by the so-called "tracer method." Fig. 61/1 shows a sketch of such an instrument described by the author in 1929.[2] Various modifications of this method have been used by various investigators in different countries. Briefly, it consists of tracing the surface with a sharp point and magnifying and recording the motions of this point by optical means. The most important factors involved are

(1) A sharp tracer must be used to reach the bottom of fine irregularities.

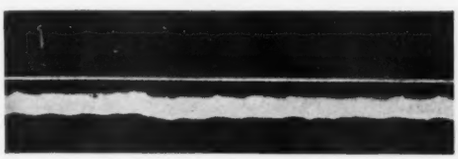
(2) Unit pressure between tracer point and surface must be small so as not to damage either the surface or the point.

(3) Magnification must be arranged so that accurate reproduction of the surface profile is obtained.

(4) Effects of vibration and other extraneous influences must be sufficiently minimized.

The author has used a phonograph needle for the tracer point and has found the instrument useful for all excepting the finest metal surfaces. Difficulty has been encountered on fine sur-

[2] "Über Glätte und Ebenheit als physikalisches und physiologisches Problem," by Gustav Schmaltz, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, Oct. 12, 1929, pp. 1461–1467.



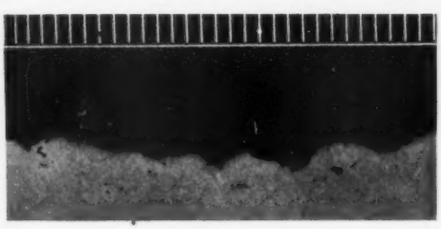
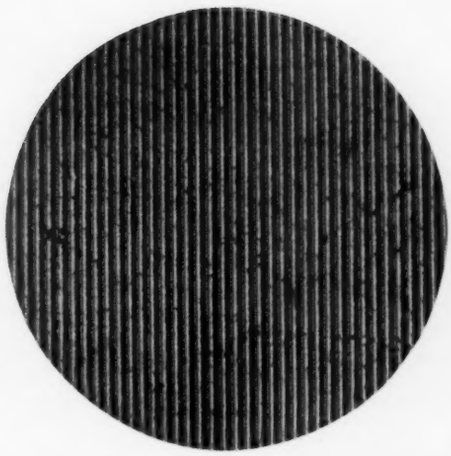


FIG. 18 STEEL TURNED WITH TUNGSTEN-CARBIDE TOOL

[(*Top*) Photomicrograph, magnification 82×; (*center*) profile microscope, magnification 82×, H = 0.00049 in., h_m = 0.00013 in., and K = 0.27 in.; (*bottom*) cross section, magnification 200×, H = 0.0013 in., h_m = 0.00058 in., and K = 0.45.]



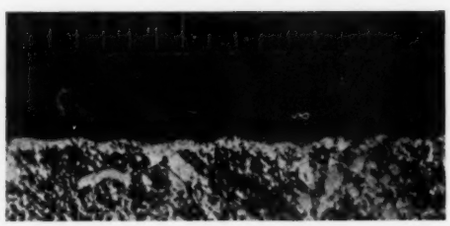


FIG. 26 ALUMINUM TURNED WITH THE FINEST DIAMOND

[(*Top*) Photomicrograph, magnification 82×, H = 0.00034 in., h_m = 0.00014 in., and K = 0.4; (*center*) profile microscope, magnification 82×, H = 0.00034 in., h_m = 0.00014 in., and K = 0.4; (*bottom*) cross section, magnification 360×, H = 0.00013 in., h_m = 0.000052 in., and K = 0.4.]

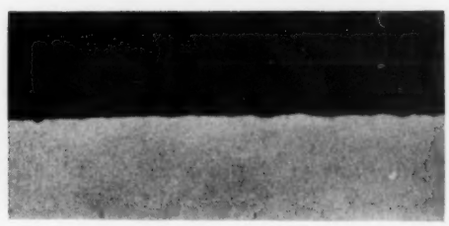
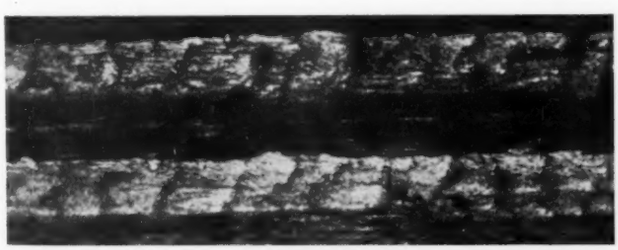
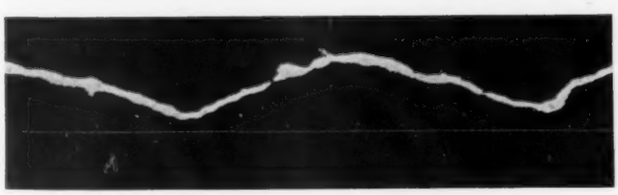
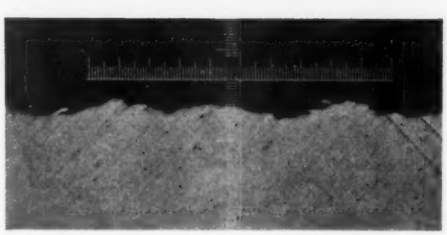


FIG. 57 POLISHED STEEL

[(*Top*) Photomicrograph, magnification 82×; (*center*) profile microscope, magnification 82×, H = 0.00024 in., h_m = 0.000052 in., and K = 0.21 in.; (*bottom*) cross section, magnification 365×, H = 0.000077 in., h_m = 0.000044 in., and K = 0.55.]







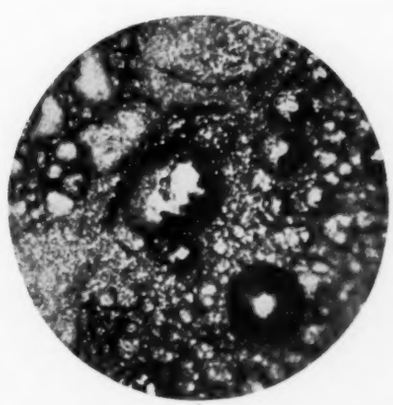


FIG. 68 TUNGSTEN—ELEMENT OF POINT OF LIGHT LAMP
(Magnification 35×.)

FIG. 1 (LEFT) ROUGH PLANED STEEL

[(*Top*) Photomicrograph, magnification 22½×; (*center*) light cross section, obtained with profile microscope, profile, magnified 74×, H = 0.004 in., h_m = 0.00186 in., and K = 0.46; (*bottom*) cut and polished cross section, magnification, 41×, H = 0.0024 in., h_m = 0.0010 in., and K = 0.42.]

faces, and the author considers the feasibility of this method on such surfaces questionable.[3] Fig. 67/1 illustrates the type of distortion obtained by the tracer method when the radius of the tip of the tracer point is not sufficiently small compared with the surface irregularities. One of the chief advantages of this method is that the horizontal magnification can be adjusted independently of the vertical, so as to cover a small portion of the specimen at high horizontal magnification for roughness studies. For waviness studies, the curve can be compressed by using small horizontal magnification so that a comparatively large portion of the specimen is covered. Microscopic methods do not have this convenience.

Impression Methods. After an impression of a portion of a surface has been made by gelatin, agar-agar, celluloid, elastine, or similar substances, sections can be cut by a microtome and examined by the methods generally used in biological science.

Cross-Section Methods. Various investigators have prepared cross sections of surfaces by cutting at an appropriate point and

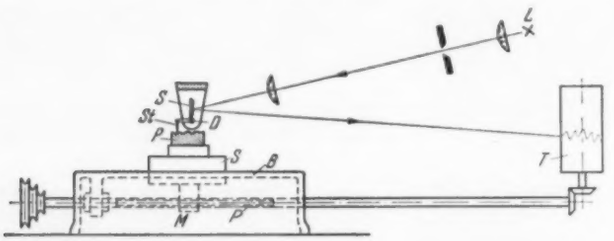


FIG. 61/1 FUNDAMENTAL ARRANGEMENT OF AN APPARATUS FOR THE INVESTIGATION OF SURFACES BY THE TRACER METHOD

(*P*, piece to be examined; *B*, bed of the apparatus; *S*, carriage; *M*, nut; *D*, point of rotation, or hinge; *S*, mirror; *L*, light source; *T*, drum with light-sensitive paper. *St*, tracer element.)

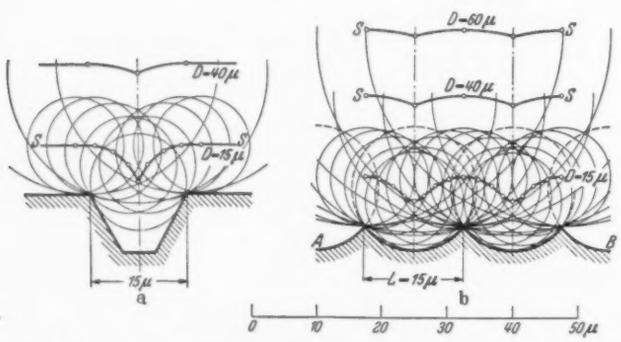


FIG. 67/1 PROFILE CURVES AND THE CORRESPONDING PATH OF THE TRACER POINT

(*A–B* is the true profile; *D*, the diameter of the tracer point; and *S–S*, the drawn curve.)

preparing a specimen by suitable grinding and polishing. Microscopic examination of the profile is then made. To reduce the damage to the profile of the specimen, the customary practice is to plate the surface or to cast it in Wood's metal, bakelite, or similar material. With care, much can be learned by this method, but one can never be certain that the profile has not been deformed in the process. This is a rather slow process and, of course, destroys the specimen.

The Light Cross-Section or Profile-Microscope Method. The author has devised an ingenious method for the rapid investigation of surfaces without damage to them. Fig. 73/1 illustrates the fundamental principle. The surface is illuminated by a narrow slit of light and viewed at nearly grazing incidence. In this way, one can actually see a section of the profile just as one can see the profile of a range of mountains while standing

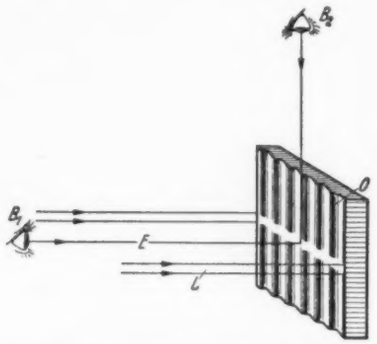


FIG. 73/1 PRINCIPLE OF THE LIGHT CROSS-SECTION METHOD

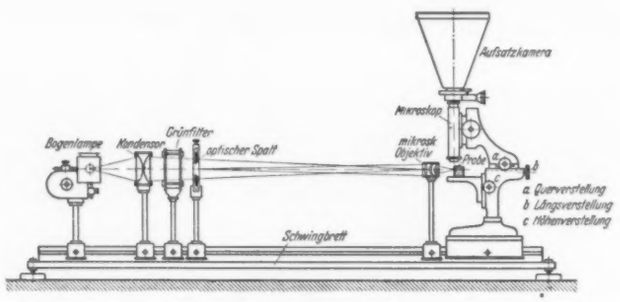


FIG. 74/1 LABORATORY SETUP FOR MICROSCOPIC INVESTIGATION OF PROFILE CURVES BY LIGHT CROSS-SECTION METHOD

on an adjacent peak. For fine work, the observation is made with the aid of a microscope.

Fig. 74/1 shows a laboratory setup for investigation of small specimens. Portable modifications of this instrument have also been devised. The essential limitation of this method is that of all microscopic examination, namely, approximately 20 to 40 microinches is the smallest distance observable. At high magnification, one sees only a very small portion of the surface, which makes it difficult to observe waviness of shallow depth and long wave length. At the end of the book are shown several scores of such pictures, together with photomicrographs, and in some cases, prepared cross sections. Typical examples are shown on page 817. These have been selected from an extensive collection of illustrations, showing the form and quality of surfaces obtained by various processes, which fills 33 pages at the end of the book.

This method is a useful contribution to the study of surfaces, especially those slightly rougher than the finest. Direct measurement of the height of irregularities can be made with a scale in the eyepiece or with a micrometer eyepiece.

Integral Methods. Several mechanical methods have been suggested for testing surfaces. Among these are a tracer with a ratchet mechanism so the recorder reads the sum of the rises in the profile and disregards the falls. Another scheme uses the surface as a brake on a pendulum. A third method measures leakage of air under pressure between the actual surface and a contacting smooth one. Still another method measures the load required to give a ball a given elastic penetration into the

[3] Recent modifications of this method made in the United States have been successful in measuring surfaces whose largest irregularities did not exceed a few microinches. These represent some of the smoothest metal surfaces available today.

surface.[4] While these methods have been found useful in certain applications, they all have serious drawbacks. The author suggests that they should be compared with actual profile records of the same surfaces to insure correct interpretation.

Physical-Chemical Integral Methods. The actual total area of a rough surface is larger than the nominal area. This ratio can be investigated by measuring the effects of various coatings of oxides, hydrogen, gas, radioactive material, and the like, and by changes in vapor pressure at high temperatures. Ratios of from 2 to 20 have been observed on common surfaces, but the accuracy is questionable.

[4] "Modern Tolerance Requirements and Their Scientific Determination," by Hilding Törnebohm, MECHANICAL ENGINEERING, vol. 58, July, 1936, pp. 411–417.

FIG. 95/1 SURFACE OF FINELY GROUND STEEL GAGE BLOCK
This is a dark-field photograph of sample L2, magnification 100×.)

FIG. 95/2 DIFFUSE REFLECTION OF THE SAMPLE THAT IS SHOWN IN FIG. 95/1

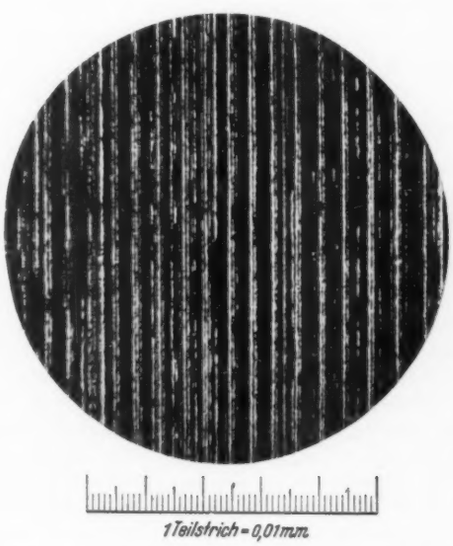


FIG. 95/4 STEEL GROUND WITH CUP GRINDER
(Dark-field photograph. Magnification 78×.)

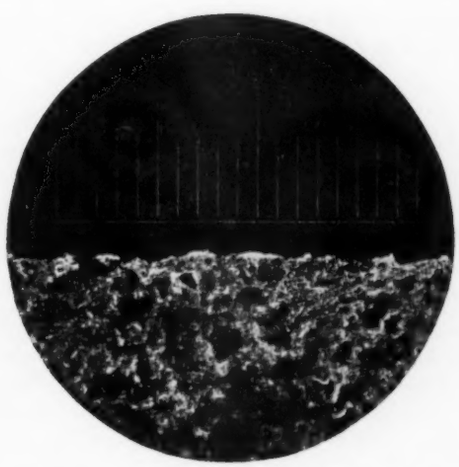


FIG. 95/5 CROSS-SECTION GRINDING OF THE SAMPLE OF FIG. 95/4, ETCHED WITH HNO_3
(Magnification 360×.)

Optical Methods. Irregularities of a surface are closely related to its reflecting characteristics, and much can be learned about a surface by investigating the light reflected from it under different conditions of illumination. The author outlines a number of methods for analyzing reflected light by distortion

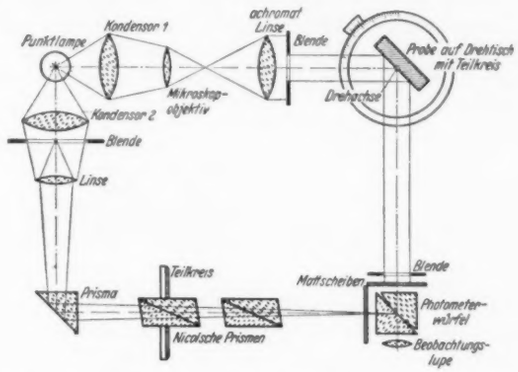


FIG. 95/3 PHOTOMETRY SETUP FOR INVESTIGATION OF REFLECTION FROM PROCESSED SURFACES

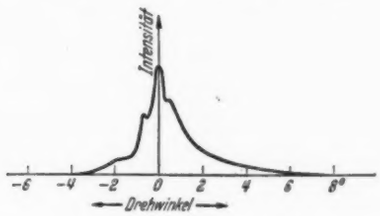


FIG. 95/6 DISTRIBUTION OF REFLECTED LIGHT OF THE SAMPLE OF FIGS. 95/4 AND 95/5, TRANSVERSE TO THE GRINDING SCRATCHES

of images, space distribution of diffuse and specular reflection, wave-length distribution, and the like. Various techniques are used including visual, photographic, and photoelectric.

The six parts of Fig. 95 show an arrangement devised by the author for measuring space distribution of reflected light. For surfaces that are exceptionally smooth, photometry of "dark-field" images has been found to be useful. Numerical evaluation of these observations is discussed at some length.

Methods With X, Electron, and Molecular Rays. As mentioned previously, microscopic magnification is limited by the failure of ordinary light to form images on account of its comparatively long wave length. With radiation of shorter wave length, such as X, electron, and molecular rays, a new difficulty arises. These rays penetrate the material and hence do not form images of the surface. Interactions with molecular and atomic structural details of the interior of the material produce peculiar patterns in the reflected or transmitted radiation. Interpretation of these patterns yields data concerning crystal structure, inner stresses, dimensions, and the like, especially for the extreme

surface layers which are of particular interest. Practical possibilities of these newer methods of analysis are yet to be determined.

Summary of Methods of Surface Testing. All of this discussion leads to the conclusion that the best means for testing and defining surfaces is in terms of the physical dimensions of the surface irregularities. This applies to both practical and scientific needs. While indirect studies by the various means outlined may be useful, they are not to be compared with direct measurements.

The three most useful methods are

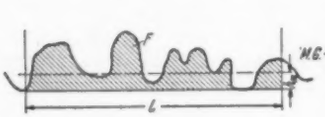


FIG. 116/1 COMPUTATION OF AVERAGE HEIGHT WITH RESPECT TO THE BASE LINE (h_m is the average height and L is the feed.)

FIG. 116/2 COMPUTATION OF THE AVERAGE HEIGHT h WITH RESPECT TO THE AVERAGE LINE M-G

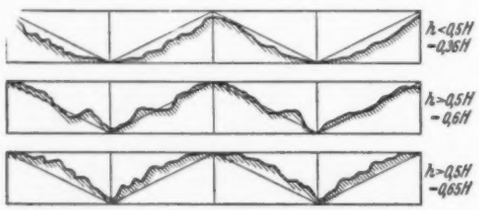


FIG. 118/1 EXAMPLES OF PROFILE CURVES WITH FORM FACTOR OR DEGREE OF FULLNESS OF 0.36 TO 0.65

(1) The tracer method.
(2) The method of sections for microscopic examination.
(3) The light cross-section or profile microscope method.

DETERMINATION OF A NUMERICAL MEASURE OF ROUGHNESS

The profile curve of a surface gives the size and shape of a number of individual irregularities. This is valuable information but it does not easily lend itself to simple numerical ratings. The author outlines several suggestions for describing profiles in terms of a few numbers. Fourier-series representation is possible but not especially useful.

By averaging the ordinates at equally spaced intervals over a typical section of a profile, the average height is obtained. This is expressed mathematically

$$h_m = \frac{1}{L}\int_A^B y\,dx$$

where

h_m = average height
L = length of a typical section A–B
y = ordinate of curve
x = abscissa of curve

This average height can be computed from a base line passing through the deepest valley of the curve, or from an average line, passing through the middle of the graph (see Figs. 116/1 and 116/2). The author prefers the former. A suggestion has been made for roughness rating in terms of the ratio of the true length of the profile to its projection on the base line, but the author sees little merit in this idea.

Form Factor or "Fullness Number." Peaks on some surfaces are blunt, while on others they are sharp. The author has invented the term "form factor" to describe this characteristic. The form factor is defined as

$$K = \frac{h_m}{H}$$

where

K = form factor
h_m = average height as defined above
H = total height of the profile

Fig. 118/1 shows surfaces of various "form factors." The form factor appears to be closely related to the wearing ability of the surface.

Another suggestion has been made to specify the character

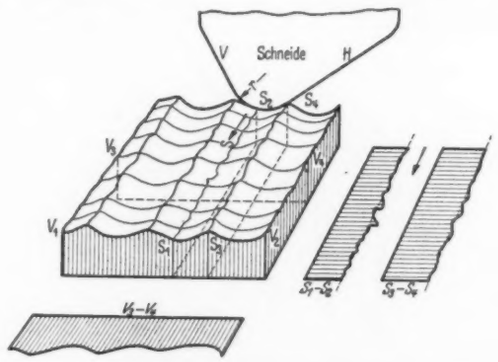


FIG. 125/1 TRANSVERSE ROUGHNESS AND LONGITUDINAL ROUGHNESS OF A SURFACE PROCESSED WITH A BIT

of the profile in terms of "peak," "medial," and "valley" distances.[5]

None of the three methods previously outlined take account of the widths of the irregularities, and hence, curves with identical values of h_m, K, and p, m, v, numbers may vary greatly in appearance.

Ordinate distribution and frequency curves are devices for further specifying the average characteristics of a profile curve by indicating the distribution of the heights and widths of the irregularities.

The ratio of height to wave length of the irregularities of different surfaces varies over wide limits, so that separate numbers must be used if both are specified.

If only two numbers are used to specify a surface profile, the author recommends the average height h_m and the form factor K.

PROCESSING OF METAL SURFACES

Material may be formed by chip removing and by chipless deformations. The most common chip-forming operations are those involving the use of tool bits, such as turning, planing, boring, milling, and the like. The author points out that grinding, polishing, and other abrasive methods are essentially similar but of finer degree.

In general, chip-removing operations produce surfaces whose profiles are different in different directions. (See Fig. 125/1.) The largest irregularities are usually shown by a profile taken at right angles to the motion of the tool across the work. To a considerable extent, size and shape of these irregularities are determined by the shape of the tool and the feed. The idealized profile shown in Fig. 126/2 is a fair approximation in many cases, and on this assumption it can be shown mathematically that

[5] "Specifying Surface Quality," by E. J. Abbott and F. A. Firestone, MECHANICAL ENGINEERING, vol. 55, September, 1933, p. 572.

(1) Total height of the profile increases as the square of the feed, and inversely with the radius of the point of the tool. It is independent of the depth of the cut.

(2) Average height, h_m, is one third of the total height H.

(3) If the feed is doubled, the radius of the tool point must be four times as great to maintain constant roughness or a constant H.

(4) Volume of material in the profile varies as the third power of the feed and inversely with the radius of the cutting point. It is independent of the depth of cut. This volume is often important in case of subsequent grinding.

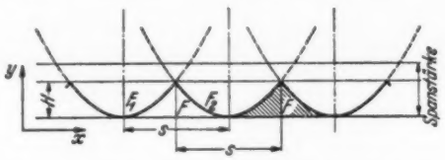


FIG. 126/2 REPRESENTATION OF THE PROFILE CURVE AS COMPOSED OF PARABOLIC SECTIONS

the material. Both surface layers and those at a considerable depth are subjected to elastic and nonelastic deformations in the cutting process, and these play an essential part in the type and qualities of the surface obtained. As indicated previously these changes in crystal formation can be studied advantageously by X rays and electron rays as well as the usual metallographic methods. A vast amount of work remains to be done in this field, both scientific and practical.

Figs. 155/1 and 155/2 show a photomicrograph and a sketch of the type of profile obtained with abrasive processes. The surface consists of a series of shallow scallops of varying depth and of somewhat varying radii of curvature, depending on the size of the abrasive grains that function essentially as tool bits on a small scale. The author points out the fact that it is practically impossible to assign a wave length to these irregularities.

Chipless Deformation of Materials. Chipless operations, such as forging, pressing, rolling, and the like, shape the materials by nonelastic deformations, with which are associated important elastic deformations. Even more than the chip-forming

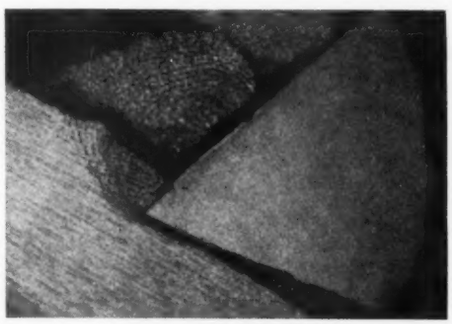


FIG. 137/1 PHOTOGRAPHS OF SHEAR CHIPS FROM A MOTION-PICTURE FILM
(Difference in time between the two photographs 0.015 sec. Exposure time, 0.2×10^{-6} sec each. V = 15 fpm; t = 0.1 in. per turn; b = 0.140 in.; γ = 15 deg; magnification 2.5×.)

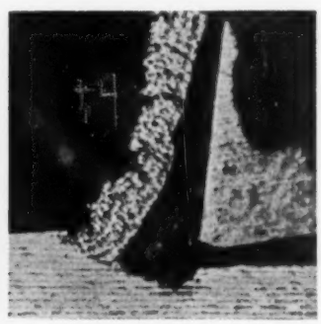


FIG. 138/1 "BUILT-UP NOSE" ON TOOL
(V = 67 fpm; t = 0.016 in. per turn; γ = 10 deg. Magnification 3×.)

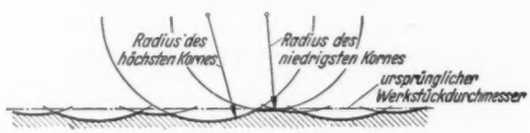


FIG. 155/2 PROFILE CURVE IN THE DIRECTION OF THE CUT ON GRINDING

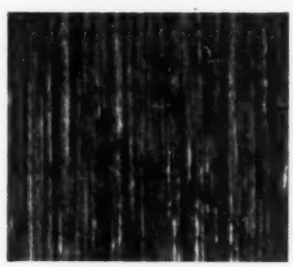


FIG. 155/1 (RIGHT) GROUND SHAFT FOR AN AMERICAN MOTORCAR
(Magnification 190×.)

Items 3 and 4 are approximations of considerable practical importance in the shop. In most cases, however, the relation of profile to feed and tool shape is not nearly as close as might be expected, because the elementary mechanism of material removal plays an important part.

In the direction of the tool motion, the profile is entirely determined by the elementary mechanism of material removal. Important factors in this mechanism are the rigidity of the machine, the tool, and the work, and the tendencies of these parts to vibration. Even more important are the characteristics of the material itself.

Studies of material removal have been made with the aid of ordinary and ultrahigh-speed motion pictures at low and high magnification. These studies show that the material is distorted at considerable distances ahead of the point (see Figs. 137/1 and 137/2). In many cases a chunk of material adheres to the face of the tool and is pushed through the material ahead of it (see Fig. 138/1). Often the material splits off well away from the tool, which leads directly to the fact that the cutting action is greatly influenced by the crystal structure of

operations, these processes are concerned with the internal structure and stresses of the material and the manner in which the structure yields to allow forming of the work. The methods of investigation here outlined also apply to these problems, and the author gives many references to work done in this field.

RELATION OF SURFACE QUALITY TO OTHER CHARACTERISTICS

Surface finish is usually of importance because of its relation to the appearance, wearing qualities, strength, or other characteristics of the surface. Until now, information on the relation of finish to these other characteristics has been quite meager, because of lack of measurements of surface quality. The author devotes a large section of 80 pages to a survey of the available material on this important question.

Surface Quality and Strength. An important effect of surface

finish has to do with the strength of the material, especially the fatigue strength for alternating stresses. Data on this effect are quite meager, although the author quotes experiments showing that the fatigue strength of materials with ordinary finish may be as much as 75 per cent less than the same materials with high polish. He suggests that the two most important factors are dimensions of the small tears or cracks in the surface and stresses in the outer layers of the material produced by the machining operation. In many cases, corrosion plays an important part in the life of materials, and surface characteristics are important in corrosion.

Actual unit pressures on the projecting portions of a surface profile are obviously much greater than the average pressure over the total area. These points of high unit stress naturally exhibit unusual wear and tendency to fatigue. The author illustrates these points by several examples.

Surface Quality and Friction. One of the principal reasons for the use of high-quality surfaces is to reduce friction, particularly on various types of bearing. This has long received the attention of many investigators. The problem is greatly complicated by lubrication. The author outlines the usual concepts of dry, fluid, and intermediate types of friction and discusses the question of surface quality in each case. Table 199/1 indicates the extreme range in dimensions of the factors that are important in the friction of lubricated surfaces.

TABLE 199/1 DIMENSIONS OF IMPORTANCE IN CONNECTION WITH LUBRICATION

Microinches (in. × 10^{-6})	
0.008–0.016	Separation between atoms of the finest protruding crystals of surfaces, as for instance, in press fits and the like; also on couplings and similar machine elements for a short time after breaking off of the crystals.
0.020–0.040	Distance of such crystal surfaces when separated by adsorbed gas and vapor films.
0.080–0.200	Distance of protruding finest surface elements separated by one or two layers of lubricant molecules as found on gage blocks, ring and plug gages, or bearings in the finest machines.
2.000	Distance from the bottoms of finest scratches caused by lapping and polishing to the crystals of a contacting plane surface. The intervening space between the two surfaces is filled with two adsorbed grease layers of 0.1 to 0.2 microinch and probably wholly or partially with unoriented molecules.
40.000 (0.00004 in.)	Thickness of a lubricating layer of the finest bearings of the finest machines.
400.000 (0.0004 in.)	Lubrication thickness of a smoothly running bearing. If the molecules of the lubricant are placed end to end, this corresponds to about 200 molecule thicknesses.
4,000.000 (0.004 in.)	Lubrication layer of a transmission bearing.[1]

Friction-time and friction-wear relations are discussed, and electrical means for determining metal-to-metal contact mentioned. The theory of fluid and semifluid lubrication is outlined. Fig. 207/1 is a schematic diagram indicating how oil molecules are bound at their ends to metal atoms and how several layers may stand somewhat on end in permanent contact with the metal, while others are distributed at random in the intervening space between the two parts of a bearing. Metal-to-metal contact is obtained when these adhering layers of oil are removed at points of high unit stress. An extensive bibliography is included in this section.

Surface Quality and Wear. The fundamental mechanism of the wear of surfaces is not clearly understood as yet, but obviously it is closely related to the surface characteristics. Figs. 214/1 to 214/4 and 221/1 and 221/2, show examples of different types of wear on surfaces. A discussion is presented on the factors involving wear for both sliding, rolling, and rolling-and-sliding contacts. The author suggests as a measure of wear the value of one half the time required to remove the original profile by wear. The fraction of the total height of the profile which is worn away in this half period gives a measure of the form factor of the surface, or, in other words, the relative importance of peaks and valleys. In many cases, wear takes place by the breaking off of pieces of material that are large compared with surface irregularities. This is caused by internal stresses in the surface layers.

Surface Quality and Fit. International standards have been set up for the clearances for various running fits and the oversize

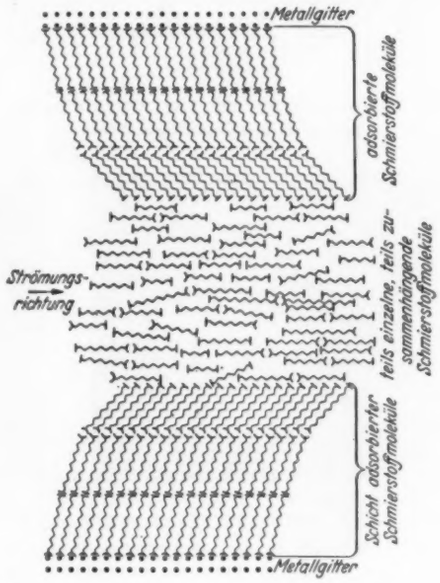


FIG. 207/1 SUPPOSED ARRANGEMENT OF THE LUBRICANT BETWEEN TWO METAL SURFACES IN MOVEMENT

(The middle flowing part is generally many orders of magnitude greater than the two outer parts. The active ends of the zigzag formed molecules are marked ⌣; the neutral ones are marked –.)

for different degrees of pressed fits. Results obtained for a given pressed or running fit are greatly affected by smoothness of the surfaces, and these should also be taken into account. As previously mentioned, wear of a given surface is greatly affected by its roughness. Hence, two surfaces may be initially constructed for a given tightness of fit, but if they differ in roughness they will not wear the same. Hence, the question of holding tolerances in different types of fit over the useful life of the piece is determined by roughness as well as by initial dimensions. These variations in running tolerances through wear are of much practical importance and are treated mathematically by the author.

Surface Quality and Force Required for Assembling Pressed Fits. The author distinguishes between three types of pressed fit, where

(1) Difference in size is materially less than the combined heights of the two surface profiles.

(2) Oversize is sufficient to fill all the empty spaces in the profile.

(3) An excess of material is found at the contacting surfaces.

In (1), deformations are essentially elastic and occur on projecting portions of the profiles. In (2), the author assumes a flow of material into the valleys of the profiles. He defines

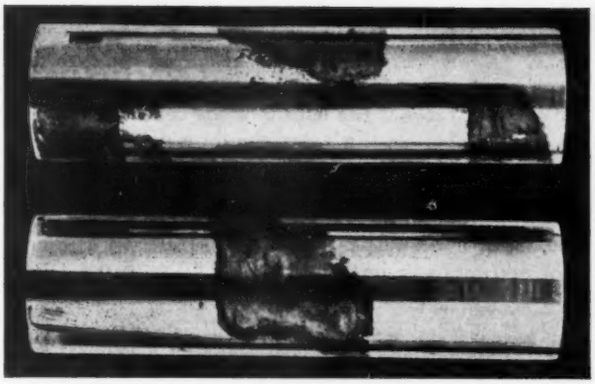


FIG. 214/1 OCCURRENCE OF "BLEEDING" OR FRICTION OXIDATION IN AN ALTERNATING BENDING TEST

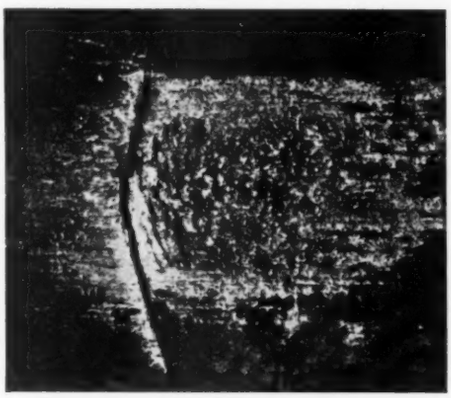


FIG. 214/2 FRICTION POINT OF A SILICON-STEEL SPRING LEAF WITH A FATIGUE-FAILURE END
(Magnification 3×.)

FIG. 214/3 CROSS SECTION THROUGH A FATIGUE-FAILURE SURFACE CRACK ON A TURBOCOMPRESSOR SHAFT
(Intensified with atmospheric nitrogen. Magnification, some 130×.)

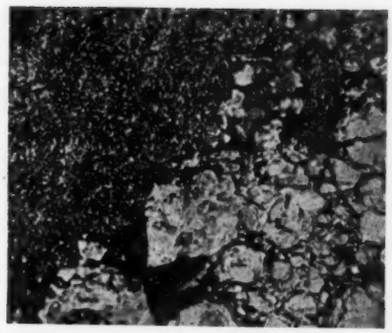


FIG. 214/4 SURFACE GRINDING OF A FRICTION POINT ON A TURBOCOMPRESSOR SHAFT; PARTS OF THE HARD BORDER LAYER ARE PRESSED INTO THE SURFACE
(Magnification 750×.)

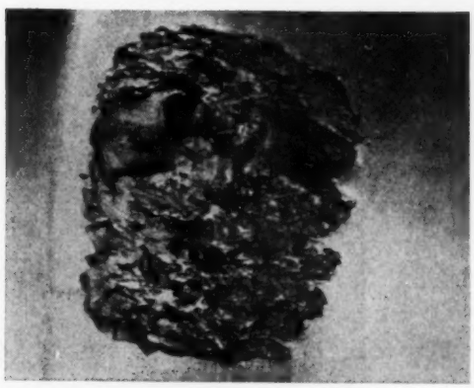


FIG. 221/1 SCALED SECTION OF A BEARING INNER RACE
(This is a typical fatigue failure. Magnification 8×.)

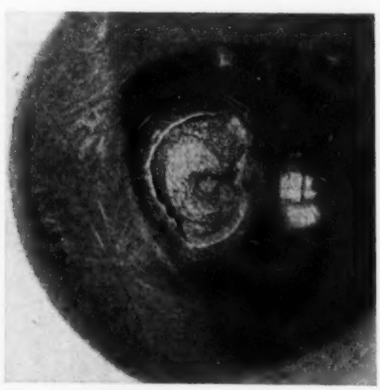


FIG. 221/2 TYPICAL FATIGUE FAILURE OF A BEARING BALL
(Magnification 4×.)

this condition as being the "flattening" distance of oversize. In (3), both plastic and elastic deformations take place. Figs. 238/1 to 238/3 are photomicrographs of the surface of plugs pressed into holes. These show evidence of interlocking and flattening of surface irregularities. Tables are included, giving the flattening distance and resulting inner stresses for various qualities of surface.

Surface Quality and Fluid Flow. Fig. 244/1 shows an arrangement where the author's light cross-section method is used to study the conditions of fluid flow in tubes having varying degrees of roughness. The long traces show approximately a laminar flow, with eddies and comparatively stationary particles near the tube walls. Pictures taken at higher magnification show definite evidence of the effect of surface irregularities. Figures indicate that these effects extend into the surface an additional distance of the same order as the dimensions of the irregularities.

Surface Quality and Heat Transfer. Character of the surface may affect all three methods of heat transfer, conduction, radiation, and convection. Conduction is particularly affected by surface quality in the case of laminated layers as in electrical machinery. The author reviews the fundamentals of these

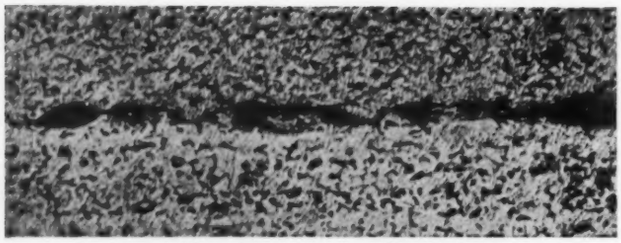


FIG. 238/1 PARTING SURFACE OF A PRESS FIT

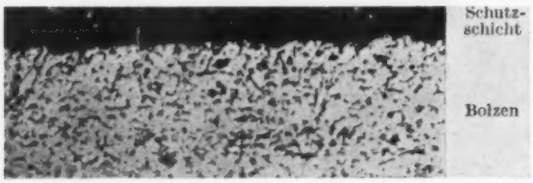


FIG. 238/2 TURNED AND GROUND PIN
(Magnification 50×.)

methods of heat transfer with special reference to surface characteristics.

Surface Quality and Condensation and Evaporation. Experiments have shown that a most important factor in heat transfer to gases in tubes is the nature of the condensation on the walls of the tube. If this takes the form of a smooth layer, the heat transfer is many times less than if condensation occurs as small droplets. Smooth surfaces inhibit sheet formations and thus greatly improve heat transfer.

One of the important characteristics of surfaces is their degree of wetting by various materials. This property is usually measured by the angle of contact of a given liquid with a material and is of importance in a wide variety of fields. While inherent characteristics of the material are the primary factor, smoothness of the surface is also important.

STANDARDIZATION OF SURFACE QUALITY

With the continued advance in the technique of processing, it becomes increasingly necessary for the designer to specify the characteristics of surfaces required for successful operation. Only when this can be done reliably, can the designer and

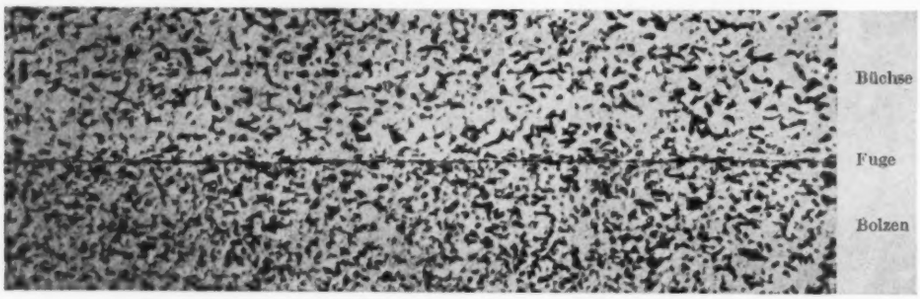


FIG. 238/3 PARTING SURFACE FOR THE PIN (FIG. 238/2) AND AREAMED COLLAR
(Oversize approximately 0.0012 in. Magnification 50×.)

FIG. 244/1 FLOW BETWEEN TWO WALLS
(Photographed with the light cross-section method. Magnification 12×. Average flow velocity 0.055 ips, 7.9 interruptions per sec.)

builder be sure that the machine will function as they intended that it should.

Previous methods of designating finish as ∇, $\nabla\nabla$, $\nabla\nabla\nabla$, and the like are far from satisfactory. It is common knowledge that tremendous differences exist in the surfaces identified by a given symbol in different shops. Individuals cannot set up the necessary standards, as this inherently requires the cooperation of experienced researchers, designers, and production men. However, it is useful to have preliminary suggestions for consideration and further development. The author emphasizes that the following ideas should be regarded solely as suggestions of this kind.

The primary requirement for a scale of surface quality is to base it on some measurable characteristic of the surface, so that it can be specified in terms of the magnitude of this quantity. To be practical for the designer and the shop man, the rating must be easy to visualize, capable of measurement, and simply related to important properties of the surface.

Microgeometry (Size and Shape of Irregularities) as Basis for Surface Standardization. Consideration of the various surface characteristics outlined in this book leads definitely to the conclusion that microgeometric form of the surface is the logical basis for specifying surface quality. In other words, size and shape of the surface irregularities are the basic factors. The problem is then one of specifying these dimensions in terms of a few numbers, preferably not more than two. In many cases the height of the profile H is sufficient. This factor, together with the average height h_m or the form factor K, cover most

ordinary needs. In special cases, one can make additional use of measurements of reflection characteristics by dark-field photometry, and other means that have been described.

Use of Standard Specimens. Many companies have used groups of specimens as a practical method of maintaining quality in the shop. These are useful for such applications, but in addition to these specimens a definite need exists for describing and specifying these and other surfaces in terms of physical units such as the centimeter or inch.

Suggested Rules for Determining Standard Degrees of Surface Quality—Rules for Determining H and h_m.

(1) Obtain a profile curve of a typical specimen of surface covering about five cycles of feed. A base line is drawn through the lowest points of the curve. Ordinarily this can be estimated sufficiently well by eye, but an average can be computed if desired.

(2) Similarly, a line is passed through the highest points of the profile curve.

(3) The distance between these lines is the height *H*. If desired, the values for several sections of profile can be averaged.

(4) If the light cross-section method is used an actual profile curve need not be obtained. Values of *H* can be read directly from the specimen by an ocular scale or a micrometer eyepiece on the microscope.

(5) In determining the upper and lower limits of the profile, unusually large irregularities are disregarded. If a rule is required, the author suggests that only those which occur at least twice in a distance of five feed cycles be included.

(6) On surfaces that have different roughness in different directions, the largest value is taken.

(7) From a profile curve, one can usually estimate h_m with sufficient accuracy, or it can be determined by a planimeter or by averaging ordinates. The ratio of h_m to *H* is by definition, the form factor K.

If the roughness of a surface is to be expressed in terms of the height of the profile *H* and the average height h_m, these distances can be given directly in centimeters or inches. If desired, a geometric scale of roughness numbers can be set up. The author suggests two series, one to be used for roughness between 40 and 4000 microinches (0.00004 and 0.004 in. or 1 to 100 microns) and the other for values above and below this range. In the range from 1 to 100 microns, he suggests a series in which each number is 60 per cent larger than the previous one, ratio $\sqrt[4]{10}$, and for the other ranges 26 per cent, ratio $\sqrt[10]{10}$.

For many cases, this graduation is rather fine, but he believes that it represents a suitable compromise for the needs of research and production. Values in these series are written as follows: 16*S*, 100*S*, and the like, where 16*S* indicates that the height *H* lies between 10 and 16 microns; 100*S*, between 62 and 100; and so on. Actual specification on drawings is made as shown in Fig. 270/1.

COMMENT BY REVIEWERS

In going over this material, I have been impressed with two points

(1) The large quantity of material which the author has drawn from work not ordinarily considered in connection with surface finish and the excellent manner in which he has correlated this material to show the various important aspects of this new field.

(2) The extremely close parallel in item after item of the author's material with the experience of the reviewers and other workers in this country.

We believe that this will long be the standard reference work in this field. The author's profile microscope is a valuable contribution, especially for rough and ordinary surfaces. Unfortunately, it is not sufficiently sensitive for the smoothest surfaces. In only a few cases are our conclusions at variance with Dr. Schmaltz's. We have been able to carry the tracer method to the point where it appears to be practicable for the finest metal surfaces, and this apparently is the only practicable method of measuring these surfaces. Determination of average height, fullness factors, and the like from profile curves is a laborious process, and a definite need exists for an instrument that will take average readings directly from the surface without the necessity of photographing profile curves and measuring ordinates. For the last two years, we have been working on the development of such an instrument in our laboratory by the use of electrical means which shows considerable promise. It is hoped to describe this instrument in an article in MECHANICAL ENGINEERING in the near future.

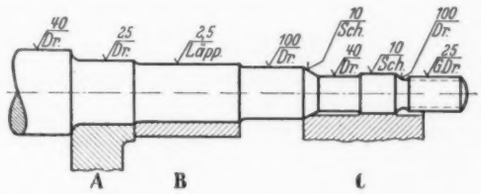


FIG. 270/1 EXAMPLE OF SURFACE SPECIFICATION ON DRAWING

Physics and the Engineering Curriculum

EFFECTIVE instruction in physics determines the quality and tempo of engineering education. Some educators have attempted, with success, to crowd the maximum of mathematics into the freshman year, thus forming the background for a more effective study of physics in the second year. Those who have tried to introduce physics in the first year have found the necessity of continuing the instruction through the sophomore year. The solution of the problems of acquiring a knowledge of mathematics and doing so soon enough would seem to lie in an effort at integrating early instruction in both physics and mathematics, limiting it in early years to those new concepts in each field which are basic to the understanding, and early introduction, of instruction in the several professional branches of engineering.

Physics departments of engineering schools may be regarded as having these three objectives:

(1) Instructing undergraduates in those principles of physical science which are essential to understanding engineering practice and developing an appreciation of the relationships in these fields which will encourage further development of their application.

(2) Developing physicists, as well as engineers, who can carry on future work in education and research which this important branch of science demands.

(3) Developing in all students, technical or nontechnical, an appreciation of the scope, place, and importance of physical science in the modern world.

Many students would profit by an engineering education, but only a portion of these will make successful engineers in a professional sense, and some should never study engineering because they have less than the minimum of ability required to profit from it. Can physics teachers in their instruction help the engineering division to solve these problems?—O. W. Eshbach, *Electrical Engineering*, October, 1937, pp. 1241–1243.

SURFACE FINISH

Straightedge-Shadow Method of Observation and Measurement

By STEWART WAY

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MODERN high standards of design and workmanship in machine building have required new investigations of the influence of surface finish on the reaction of parts to various operating conditions. Surface finish is found, for example, to influence fatigue strength of parts submitted to fluctuating stresses, tightness of press fits, and resistance to wear of sliding surfaces.

To compare finishes or differentiate between them, it is necessary to observe and measure them. Many devices have been developed to accomplish this purpose. This paper will not present an exhaustive survey of this field but rather will describe one particularly simple method that has been found by the author to give satisfactory results. It possesses the merits of requiring no unusual and costly apparatus and of giving complete information concerning the character of the surface. The method also has, of course, certain limitations which will be mentioned.

DISCUSSION OF VARIOUS METHODS

Before describing the device used by the author, a short discussion of various methods of attacking the problem is in order. For a complete survey of the field, the reader may refer to a recent book by Schmaltz (1).[1] Methods can be grouped under three headings:

(*a*) Qualitative methods.
(*b*) Methods giving a parameter related to roughness.
(*c*) Methods giving a picture of the profile.

In the qualitative study of surface finish, the object is to compare the finish on a part with that on a standard sample. To do this satisfactorily, both pieces must be of the same material, have finishes produced by the same process, and, when the comparison is made, be illuminated in exactly the same manner. Microscopes are made for viewing simultaneously the surfaces of the two pieces, under identical illumination conditions, side by side in the field of the instrument. The stereomicroscope may also be classed as an instrument well-suited to the qualitative study of surface finish. It has the advantage that the depth of the irregularities can be estimated, and perhaps for this reason it should be classed with the second group of methods.

Several methods of studying finish yield a parameter associated with the nature of the surface. Perhaps the simplest, though of limited application, is to use the surface as a mirror (2). If i is the angle between a ray of light coming from an object and the surface, the maximum value of i for which the surface acts effectively as a mirror is given approximately by $\sin i = \frac{1}{8}\,\lambda/\delta$, where λ is the wave length of the light and δ is the average depth of the "valleys." Another method of obtaining an index number of roughness is to draw a needle point over the surface, which is made to actuate a magnetic pickup and generate an alternating-current voltage. A variation of this scheme is to have the moving needle vary the capacitance of a condenser. J. Perthen (3) has a method of studying the average departure of a surface from a true surface, plane or cylinder, in which the surface being studied is used as one plate of a condenser, the capacitance of which is measured. Another method of obtaining an index number for roughness utilizes its effect on the depth of a Brinell impression under a given load (4).

Surfaces may have the same average depth of irregularities or the same roughness index as given by one of the foregoing methods and yet exhibit widely different behavior under certain conditions. If the methods of producing the finishes as well as the parameter values are the same for several surfaces, the properties would be expected to be in more uniform agreement. However, it is often desirable to know the actual shape of the surface to understand what is really taking place in a certain situation where events are influenced by roughness. The shape of the surface usually changes with time. If means are available for obtaining a picture of the surface, as many descriptive parameters as we like can be determined, and also the changes that take place in the surface can be followed.

The most direct way to obtain a profile view of a surface is to cut the piece, mount it in a suitable material, as Wood's metal, polish it, and examine the edge with a microscope. Sometimes copperplating is advisable to reinforce the edge during polishing (5). This sectioning process has the disadvantage of destroying the piece examined.

If the sample cannot be sectioned or destroyed, one of three general methods can be followed. The first of these might be called the mold process (6). A gelatin or celluloid mold is made of the surface, which is then sectioned with a microtome and examined with the microscope. The second possible procedure is to use a needle moving over the surface, the vertical motion of which is magnified either mechanically or optically and then recorded. Schmaltz (1) and Kiesewetter (2) in Germany and Abbott and Firestone (7) in this country have developed instruments of this type. Accuracy of the record of the surface profile will depend on the radius of the needle point and freedom from clearance and vibration of the moving parts. The third method of obtaining a profile picture is to produce an outline of the surface by optical means. To this end Schmaltz (1) has developed a straightedge projection device, which is described later in the paper. The author has used a straightedge shadow process. A microinterferometer, developed by Linnik (8), enables one to obtain a contour map of a limited portion of the surface. This method enables us to study the finest irregularities and is well-suited only for finely polished surfaces.

THE STRAIGHTEDGE-SHADOW METHOD

If a straightedge be placed against a corrugated surface and illuminated by a narrow rectangular source of light, as shown in Fig. 1, the edge will produce a shadow on the surface, the

[1] Numbers in parentheses refer to the Bibliography at the end of paper.

Contributed by the Special Research Committee on Lubrication for presentation at the Annual Meeting, New York, N. Y., Dec. 6–10, 1937, of The American Society of Mechanical Engineers.

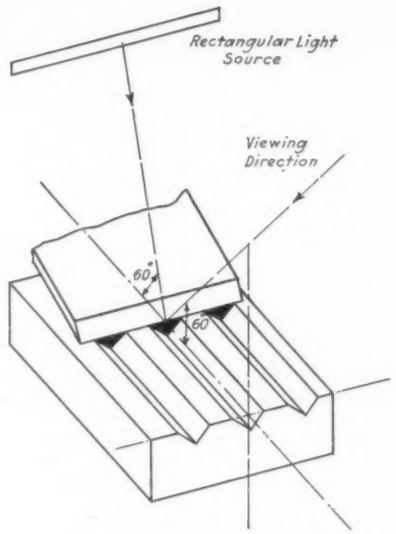

FIG. 1 PRINCIPLE OF STRAIGHTEDGE-SHADOW METHOD

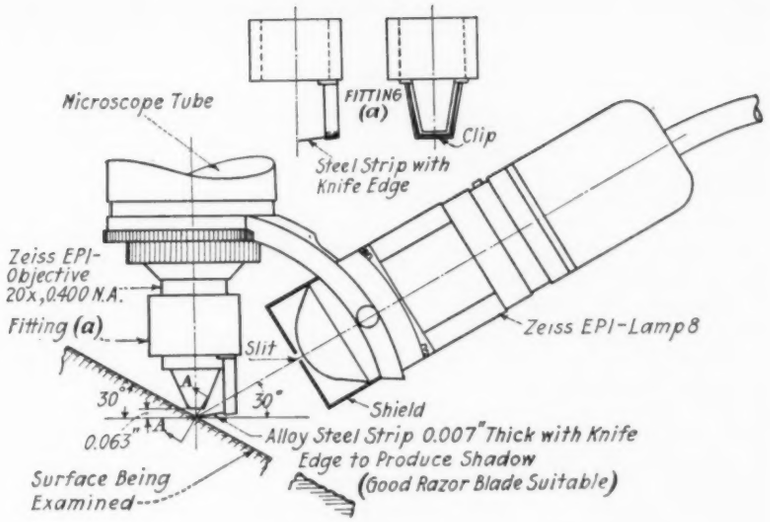

FIG. 2 SURFACE-FINISH TESTER

projection of which on a certain plane will indicate the true shape of the profile. The shadow of the straightedge can be examined with a microscope at the proper angle, and a permanent record made by taking a photograph. Fig. 2 shows the arrangement of the apparatus used by the author. Light strikes the surface at an angle of 60 deg and observation is also at an angle of 60 deg with the surface. Using these angles permits observation of the true shape of the profile and also furnishes maximum illumination, which is convenient for taking photographs.

In the Schmaltz straightedge-projection method, often called the "light-cut" method, a microscope objective is used to focus the image of a straightedge on the surface being examined and this image is in turn observed from a different angle by a microscope. The source of light, straightedge, projector, and microscope can be mounted together in one unit. Zeiss now produces such instruments.

In the setup used by the author, it was found convenient to use a Zeiss "Epi-lamp 8" as illuminator. For medium magnification an achromatic objective of 0.200 numerical aperture, 8× nominal magnification, was used and for higher magnification the Zeiss "Epi" achromatic objective, 20×, was especially useful because of the small diameter of its end. The working distance of this objective is 1.6 mm and the numerical aperture is 0.400. With this objective two objects closer together than 0.00002 in. would appear as one when viewed in green light. This figure, indicating the resolving power, could be decreased by using higher numerical apertures, but this would be possible only with smaller working distances. It is difficult to mount and illuminate a straightedge in less than 1.6 mm working distance, although it could be done, if necessary. A 17× ocular was used for most of the observations giving a total magnification of 340×. With this equipment irregularities smaller than 0.00005 in. in height could be observed.

For a straightedge a section of safety-razor blade was used. Fig. 3 shows this blade at 400 magnification against a light background. Each small scale division is 0.0002 in. Practically no notches in the edge are detectable. Any notch that was present could produce a corresponding notch in the shadow only half as deep, on account of the angles of illumination and viewing which were chosen. The razor-blade pieces

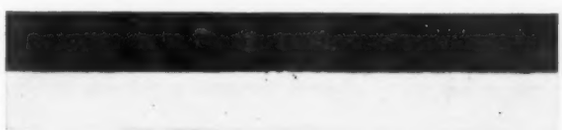

FIG. 3 SECTION OF SAFETY-RAZOR BLADE USED AS STRAIGHTEDGE (Magnification is 400×.)

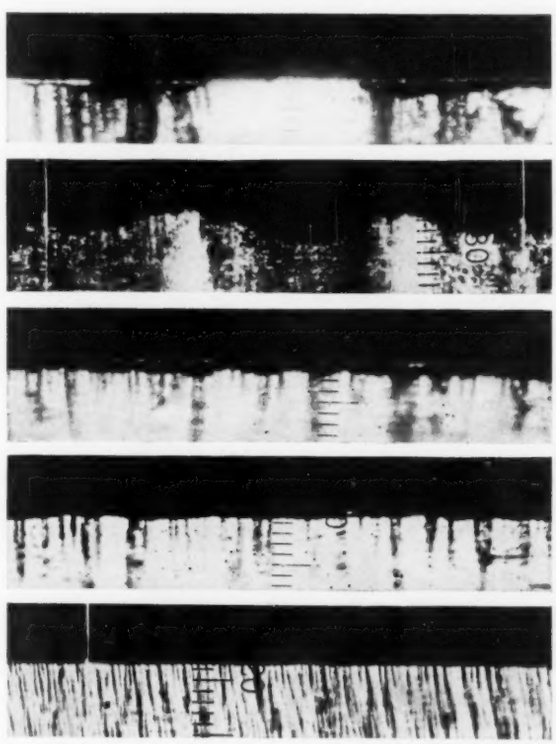

FIG. 4 PHOTOMICROGRAPHS MADE WITH THE STRAIGHTEDGE-SHADOW APPARATUS

(From top to bottom, they are gear tooth, magnified 136×; a finely turned surface; a ground surface; a finely ground surface; and cold-rolled strip steel used for flapper valves in refrigeration compressors, all magnified 340×.)

have the disadvantage of soon wearing out. However, they are very easily replaced by inserting new ones in the supporting clip.

PROFILES OF VARIOUS SURFACES

In Fig. 4 are shown a number of photomicrographs made with the straightedge-shadow apparatus. The top view is the surface of a gear tooth at 136 magnification, each small scale division being 0.00049 in. The other views are, respectively, a finely turned surface, a ground surface, a finely ground surface, and the surface of a piece of cold-rolled steel strip used for refrigeration-compressor flapper valves. In the latter four illustrations, each small scale division is about 0.0002 in. and the magnification is 340.

The straightedge-shadow method is seen to enable us to observe irregularities as small as 0.00003 to 0.00005 in. in height. Coarse irregularities can also be studied by this means with great ease. The Schmaltz instrument is probably capable of portraying irregularities as small as 0.0001 in. when carefully used. The limitations of needle-tracing instruments have already been mentioned. Sectioning and microscopic examination, using a high numerical aperture and ultraviolet illumination, might make possible the observation of irregularities as small as 0.00001 in. For finer surfaces than this, observation with a microinterferometer would probably be necessary.

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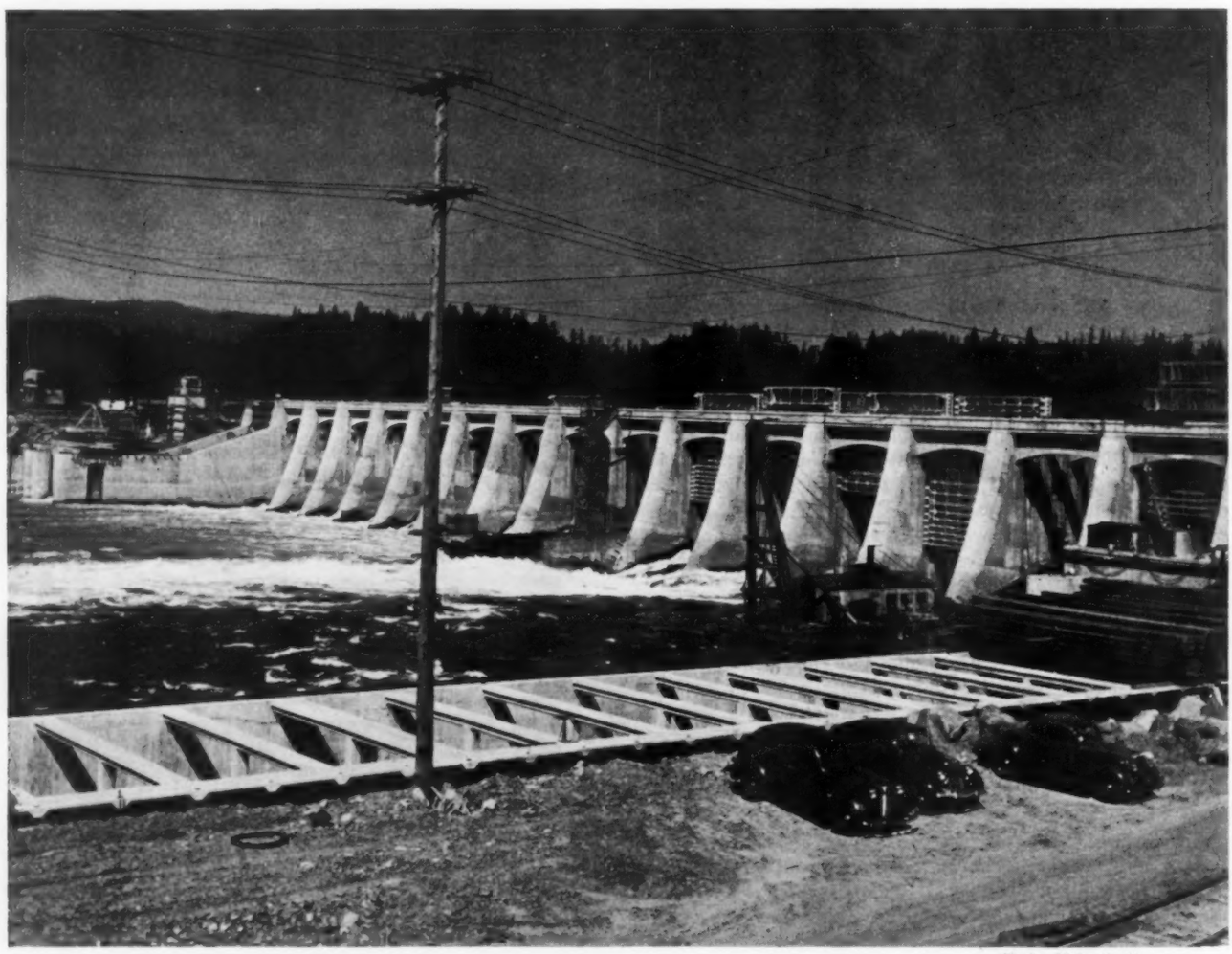

Charles Phelps Cushing

SLUICEWAYS OF BONNEVILLE DAM ON THE COLUMBIA RIVER, WITH FISH LADDER IN FOREGROUND

Status of Our Knowledge of COAL SELECTION *for* STEAM-GENERATING EQUIPMENT

By R. A. SHERMAN

BATTELLE MEMORIAL INSTITUTE, COLUMBUS, OHIO

ALTHOUGH this occasion is by no means the first time that the selection of coal for use under boilers has been considered at meetings of the Society, it is outstanding as being the first time that the subject has been discussed in a joint meeting with the Coal Division of the American Institute of Mining and Metallurgical Engineers and an attempt has been made to cover, in one session, the several types of fuel-burning equipment. As papers have been presented on traveling-grate and large and small underfeed stokers and pulverized-coal burners only one important type of equipment has been omitted. That is the spreader stoker, and it was omitted from this session only because it had been so well-covered in the paper by Barkley (1)[1] at the last Semi-Annual Meeting of the Society.

This paper will review the papers on the selection of coal for the five types of burning equipment, summarize the characteristics of coal that are important in all types of combustion and those that are distinctive to certain types, and consider how our knowledge could be improved and along what lines our further search for knowledge on coal and on burning equipment might profitably be directed. No detailed discussion of the individual papers will be presented, as that will have been amply covered in the discussions presented at this meeting.

STATUS OF OUR KNOWLEDGE AS INDICATED BY THE PAPERS

Coal has been burned under boilers for over 100 years. The principle of the stoker has been in use for about 50 years. Pulverized coal has been burned under boilers for over 20 years. Many of our present analytical tests for the characteristics of coal have been standardized for over 20 years. Users of coal by the thousands have had to choose coal for their equipment in all that time. Most of these have had to make their choice of one of several seams, one of many mines in each seam, and one of a number of different sizes produced by that particular mine.

With this background, one unacquainted with the field might have expected that each of the several authors could have written a concise paper in which he set down assured facts in regard to the effect of different characteristics of coal on the performance of each type of stoker or burner with definite rules for selection of coal. Not one has given general rules for the selection of coal, and as a matter of fact some of the papers omit almost entirely any reference to the characteristics of coal.

One might conclude, and rightly, that the authors felt that the subject was of too great a scope for full coverage in a paper of a few thousand words. However, one is apt to suspect that few users have selected coal in the past and that most of it has been merely chosen. The distinction between choice and selection used here is that given in Crabb's English Synonyms as follows: "Choosing is not always an act of particular design or discrimination; to pick and select signify to choose with care." Concrete evidence is given in the paper by Tobey (2) when he says of the 18 coals found suitable for use out of 130 tested, "Of the entire 18 not one was found to have been included in the original lot of coals which were on the approved list." This, the reader will recall, was not a small plant but one which burned up to 700 tons of coal per day. If this was true for such a plant, what must be the conditions that prevail in the thousands of smaller plants located in all parts of the country?

If the user is not equipped with the knowledge of how to select his coals, one must also believe that the equipment manufacturer does not have this knowledge or he would have passed it along to the user when the equipment was installed. A similar conclusion is reached by perusal of manufacturers' descriptive literature, for any reference to the characteristics of coal is generally noticeably absent. If reference is made to coal types, the thought is frequently inferred, and sometimes stated, that this particular equipment will burn any coal satisfactorily. The third party involved, the coal producer, must likewise be lacking in information or if he has it he must suppress it in his enthusiasm to obtain an order, for, needless to say, many coals have had trials in plants where they never should have been used.

That the subject of coal selection is complex is indicated by the Report to the American Standards Association's Technical Committee on Coal Classification (3), which was made by the National Committee on Coal of the National Association of Purchasing Agents. This committee, with T. W. Harris, Jr., as its chairman, was charged with the determination of technical factors for consideration in selecting coal and was assisted in its work by many qualified men in the field. In the charts for the selection of coal for steam generation, the characteristics of coal are listed under 32 items, and each of these must be considered with relation to the factors of equipment and type of installation which, for some types of equipment, number as many as 9. One can imagine the confusion that arises in the mind of a purchasing agent when he first looks to this chart for assistance in the selection of the proper coal for use in his plant.

The American Society for Testing Materials has 12 Standards and 4 Tentative Standards on Methods of Testing Coal. One of the former, that on laboratory sampling of coal and coke, includes a number of standard methods, from laboratory sampling to determination of the softening temperature of ash. Some of these standards were adopted as early as 1916 and have been used and revised since that time. Despite their constant use, some uncertainty arises from time to time as to the significance of the results of the tests. Only this year, Committee D-5 on Coal and Coke held a symposium (4) in which authorities on

Contributed by the Fuels Division and presented at the Fuels Meeting, Pittsburgh, Pa., Oct. 27–28, 1937, held under the joint auspices of the Fuels Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS and the Coal Division of the American Institute of Mining and Metallurgical Engineers.

[1] Numbers in parentheses refer to the Bibliography at end of paper.

the various tests presented papers that inquired into the significance of the various tests.

The fact that such a symposium was held, that this symposium is in progress, and that the National Association of Purchasing Agents has given consideration to the subject are excellent signs. Although we have been drifting at sea much too long, we now realize that we are at sea and navigators are busy with their sextants looking for the sun, or making artificial horizons on which to sight so that our position may be definitely determined and we may in the future steer the proper course.

Inasmuch as the papers under consideration indicate that the selection of coal for steam generation is a difficult and complex task, let us inquire into the reasons why this should be true and what steps can be taken to alleviate the situation.

FACTORS CONCERNING EQUIPMENT

The purchaser of coal has certain steam-generating equipment in his plant with which he must carry the load. Fundamental requirements to be met by the coal with this equipment which can be set down will be somewhat as follows:

(1) Dependability
  (*a*) Ability to carry the load
  (*b*) Ability to respond quickly to change of load
(2) Economy
  (*a*) Cost of heat in coal as delivered
  (*b*) Cost of crushing or pulverizing preparation in the plant
  (*c*) Efficiency possible with given equipment
  (*d*) Maintenance costs chargeable to coal
  (*e*) Labor costs chargeable to coal
(3) Cleanliness
  (*a*) Dust
  (*b*) Smoke

Three principal requirements must be satisfied, but above all is the item of dependability. This may, and often does, lead to the situation where the most economical coal as measured by the cost per 1000 lb of steam, including all maintenance and labor costs, may not be the coal to use because it will not carry the load. This may be the result of excessive clinkering, excessive smoke at heavy loads, or several other causes, but it will compel the purchaser to use a less economical coal.

It would seem obvious that an analysis of his plant with limitations for each of these factors, a statement of the physical details of the plant, and a statement of the condition of the plant would have been made by any purchaser. This would serve as a guide for himself and for the coal salesman or fuel engineer who is offering coal for sale. As Tobey has pointed out in his paper (2), many industrial boiler installations are old and in need of repair. A similar situation, although more acute, is found in every survey of fuel-burning equipment in homes. Condition of the equipment should always be analyzed for consideration whether an expenditure for revamping or for new equipment might not lead to using a more economical coal and lower over-all costs for steam.

One is led to suspect, however, that many plants do not have this clear-cut analysis of the condition and demands of their equipment. The purchaser himself does not realize the relation of his equipment to the coal that he is purchasing, and the coal salesman is in the dark as to whether the coal that he offers will fit the needs of the plant. Many salesmen and fuel engineers of producers make surveys of plants in this manner at every opportunity, but chief engineers dislike continued surveys by representatives of different companies. If a standard form were intelligently and honestly filled out, much good could be accomplished.

FACTORS CONCERNING COAL

As previously stated, the report of the National Association of Purchasing Agents (3) breaks down the characteristics of coal into 32 items, but in the papers that have been presented the following stand out as those of greatest importance:

(1) Calorific value
(2) Characteristics of ash
  (*a*) Amount
  (*b*) Fusion characteristics
(3) Coking characteristics
(4) Size
(5) Volatile content
(6) Crushing characteristics
  (*a*) Friability
  (*b*) Grindability
(7) Ignitibility and rate of burning

Of these several characteristics, we have Standards or Tentative Standards of the American Society for Testing Materials (5) for calorific value, ash content, ash-softening temperature, size, volatile content, friability, and grindability. Definite values for these characteristics can, therefore, be determined on any sample of coal. Difficulties arise, however, in evaluating the significance of each of these factors in their effect on the efficiency with which the heat in the coal can be converted into heat in the steam and how each affects the total cost.

The previously mentioned symposium of the American Society for Testing Materials presented the most recent thought on the significance of the standard tests, except the factor of size which was not included in the symposium. One conclusion of the symposium was that fusibility of ash as now determined is an important item of information concerning coal but that much more research needs to be done before we can predict accurately the clinkering and slagging difficulties.

Volatile content is important in regard to smoking tendencies of coal. It is, however, not the only criterion of this tendency of a coal, as two coals of similar volatile content may emit entirely different quantities of smoke under similar conditions. Other factors, of which quality of the volatile matter is the principal one, are likewise important. Need exists for a standard method for determining the inherent smoking tendencies of coal.

Although size of coal is a characteristic that is readily measured and one over which the producer has some control, authoritative data on the effect of size of coal on the performance of coal on large stokers are now lacking. For Bituminous Coal Research, Inc., data have been obtained at Battelle Memorial Institute on the effect of size on the performance of the small underfeed stoker (6). Similar data are needed for the large stoker.

All coals leave a carbonized residue as they are heated and the volatile content is driven off. Size and strength of this residual coke mass are of great importance in the combustion of coal on a stoker because, expressed in its simplest form, the type of coke determines the size of the fuel that is burned. Coking characteristics of coal are extremely variable among seams and even within the same seam and in different sizes from a seam.

Because of the importance of the coking characteristics that have been mentioned by Anbro (7) in connection with traveling-grate stokers and have been particularly stressed by Tobey (2) in relation to underfeed stokers, it is unfortunate that we have no method for their measurement. Even in coke-making practice, where these properties are obviously of great importance, a large amount of research has not developed an agreed

and standard method for determining this property. Recently, however, Subcommittee XV on the Plasticity and Swelling of Coal has been formed under Committee D-5 of the American Society for Testing Materials and has been charged with consideration of methods for test not only in relation to coke-oven practice but also in relation to combustion.

Ignitibility is a term that is meant to include ignition temperature and rate of reaction at that temperature. Ignition temperature of solid fuels has been the subject of research in the past which has resulted in several methods for its determination. Renewed interest has developed in the subject because of the suggestion from the work of Nicholls and Eilers (8) on combustion in underfeed fuel beds and from mathematical analyses of combustion made by Mayers (9) that the ignitibility of a coal is an extremely important factor in this type of combustion. In recognition of this interest, Committee D-5 of the American Society for Testing Materials has authorized formation of Subcommittee XVI on the Ignitibility of Coal and Coke which will attempt to develop a standard test method.

The term, rate of burning, is suggested as a distinct characteristic of coal, although it is probably related to the coking characteristics as they affect the size of coke masses in a stoker. Some evidence is available to prove that reactivity of the resultant coke varies with different coals, and if so this is probably due to characteristics of the coal. The terms "flashy" and "slow-burning" are often applied to coals, but their meaning is not generally clear. Rate of burning of the solid carbon is an important factor in the combustion of pulverized coal, particularly if the combustion rate is restricted. The general relation of volatile matter to rate of burning of pulverized coal is fairly well-known, but differences exist in the rates of burning of coals having similar volatile contents and little is known of this characteristic.

Rate of burning must be considered together with the factor of grindability in selecting coal for pulverization. Nature has made the beneficent arrangement that low-volatile coals, which must be more finely pulverized than the high-volatile ones to burn completely in the same space, are softer, that is, they have a higher grindability index. That softer coals do require a longer burning time is at times forgotten and grindability, being a relatively new determination on coal, is sometimes given greater importance by producer and user than it deserves. Hardgrove (10) has also pointed out that a considerable difference in grindability may make little difference in grinding costs. Grindability is of great importance as shown by Tate (11), when it determines the capacity that can be obtained from a given unit.

From this brief consideration, therefore, it can be answered that coal selection is difficult because (*a*) the problem is complex, that is, numerous factors of equipment and coal characteristics are involved, (*b*) a number of important characteristics of coal are not yet subject to definite laboratory measurement, and (*c*) the relations of some measurable characteristics to performance of the coal are not definitely known.

Having roughly determined our present position, let us consider what is to be done in the future by joint efforts of the producer and the user of coal and the equipment manufacturer to make proper selection of coal less difficult. In this consideration we may divide the problem into two parts: (*a*) steps to be taken in the immediate future, and (*b*) those to be taken in the more distant future.

THE IMMEDIATE FUTURE

Although we have admitted that the problem of coal selection is complex and that much remains to be learned about coal and its use, it does not seem reasonable to grant that the subject even now is a mystery in the sense of being forever unfathomable. Some take this attitude when they say that every installation is special and when they cite instances of failure or success of coals in certain places with no known reason. Enough information is available on all of the coals mined in the United States and the effect of their characteristics on the performance of all types of equipment that, if that knowledge were applied in each installation, selecting coal would not resolve itself into a trial shipment of every coal available to the plant but should narrow itself down to a relatively few. Nor would users continue to shift from one source of supply to another.

Probably the difficulty is that available knowledge is not being utilized. Lack of utilization of available information is not confined to the small plant but is also found in the large plant. It is more pronounced in the smaller plants, because the information in the literature often is not available to engineers and others concerned with the purchase of coal. Engineers of these plants are not often members of the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, or American Society for Testing Materials. As Tobey (2) has said in his paper, "This, and other papers given at this meeting, will probably not reach those who supervise the operation of this average-size plant." Frequently, even the journals of the power field are not received by them. What knowledge they do possess is not properly considered and regarded by the purchasing agent or other official who orders the coal.

Available knowledge is now widely scattered and nowhere concisely presented. When one considers the books and more books published on more and more subjects, he is impressed by the lack of books on the subject of coal and its combustion. "Combustion in the Power Plant," by T. A. Marsh is now out of print and unobtainable; "Fuels and Their Combustion," by R. T. Haslam and R. P. Russell, is 11 years old.

The American Society for Testing Materials again promises to be helpful. A book comprising the symposium on the significance of tests of coal together with the discussion presented at its last annual meeting is to be prepared. This will be a valuable aid to the engineer of the large power plants. Recognizing the need for a different approach to the subject for the smaller plant, Subcommittee XVII has been commissioned to prepare a series of booklets or manuals on selection and purchase of coal. The exact nature of these books has not been determined, as the subcommittee has just been organized, but Bituminous Coal Research, Inc., will cooperate by making available the time of a man to compile the information with the assistance of other members of the committee.

THE MORE DISTANT FUTURE

While this process of education is going on to promote intelligent use of the information that we now have on the selection of coal, research on the unknown factors will continue. Universities, the Bureau of Mines, private institutions, coal producers and users, and equipment manufacturers will continue to work toward the solution of these problems. We can picture a future time, therefore, at which we will be able to assign definite values to clinkering and smoking tendencies, size, coking characteristics, or ignitibility of coal and in a similar way fix various ranges of suitability for each of these characteristics with different types of burning equipment. This picture would be bright indeed and a tremendous advance over our present state of knowledge.

Can we not, however, aim at a still higher ideal situation than this? Coal will probably remain our basic fuel. More power plants will be needed and burning equipment in present

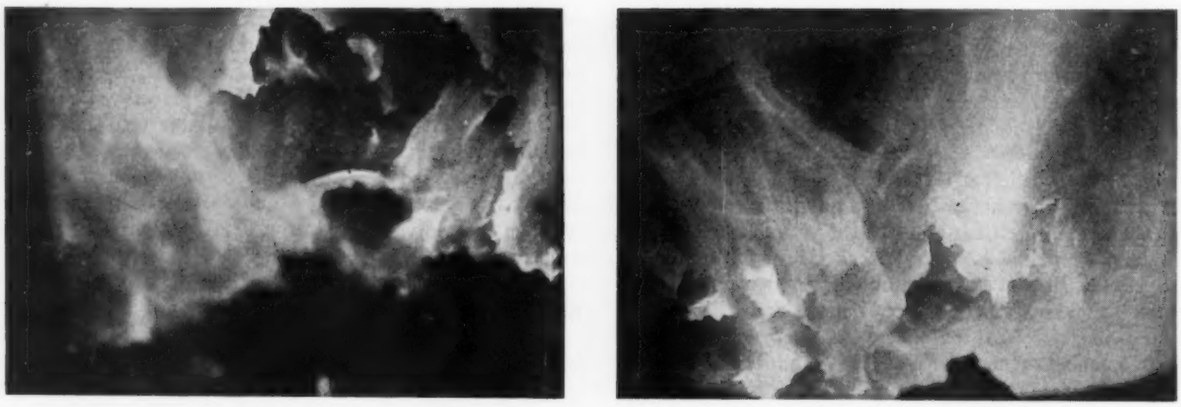

FIG. 1 TYPES OF FUEL BED OBTAINED IN A SMALL UNDERFEED STOKER BURNING 0 × 3/4-IN. MODERATELY STRONGLY COKING PITTSBURGH COAL

(The bed shown at the left was obtained without the agitator; in the bed shown at the right the agitator was used. Differences in the type of bed and the absence of coke trees when the agitator was used can be clearly seen.)

plants will wear out, become obsolete, and be replaced. Should our ideal not be the perfection of equipment that is not particular as to the type of coal, a stoker, large or small, to which it is immaterial whether the coal is free-burning or strongly coking, a pulverized-coal burner to which it is immaterial whether the coal is 17 or 37 per cent volatile? Selection of coal would then resolve itself into a determination of calorific value and a quotation on the price of the coal; ash, sulphur, and moisture contents, the negative values, as Gould (*4b*) has called them, would then be largely immaterial.

Accomplishment of such an aim will require both research and invention, research to determine the facts and invention to apply these facts to practical combustion equipment. Research on the process of combustion as it occurs in equipment has until recently been lacking and development of equipment has probably not proceeded as rapidly as it might have if knowledge of what was going on in the fuel bed or flame had been available.

THE SMALL STOKER

The small underfeed stoker of today as designed and sold for residential heating with bituminous coal has the great merit of simplicity. From a hopper, the worm, driven at low speed through a transmission from the motor, feeds the coal upward into a retort, and a fan on the motor shaft supplies air for combustion through tuyères in the retort. A damper, automatically or manually controlled, determines the volume of air supplied. Guthrie (12) has described how these stokers, when fitted with thermostatic controls and given coals reasonably suited to them, will burn coal with minimum attention.

Research at Battelle Memorial Institute for Bituminous Coal Research, Inc., (6) has shown, however, that feeding by the screw crushes the coal to a considerable degree and tends to segregate the fine and coarse coal in the fuel bed. Lack of uniformity of combustion over the fuel bed is a result. Developments to minimize the crushing and segregation would seem to be in order.

The formation of "coke trees" in the fuel bed is a natural result of quick heating of the coal and lack of agitation in the bed (13). Although these coke trees make a ragged fuel bed, combustion is efficient up to a certain degree of coking. With strongly coking coals, difficulties follow, the most serious of these being loss of ignition; the fire goes out. In many parts of this country, available coals include many that are not too strongly coking for these stokers but in others the logical and economical coal for domestic use is a local strongly coking coal. In these districts, the small stoker does not meet with great success. Furthermore, these stokers become sensitive to size with more strongly coking coals. A stoker that functions satisfactorily with a coal from which particles smaller than 1/4 in. have been removed may have difficulty if finer fuel is supplied.

TESTS OF FUEL-BED AGITATOR

Proposals have been made from time to time of systems for agitating the fuel bed in the small stoker to keep the bed broken up. At Battelle Memorial Institute we have recently conducted a series of tests for Bituminous Coal Research, Inc., on a device of this type which had been used to some extent in the field and appeared to have definite promise. The agitator consisted of a section of a steel ring of circular cross section. The diameter of the agitator was 2 inches. It entered the back of the retort near the bottom and was driven through a linkage to a crankarm which was geared to the shaft driving the feed screw. In the model under test, the agitator made four strokes to each revolution of the screw. As the stoker was of the type in which the screw moved intermittently, the agitator was pushed into and withdrawn from the fuel bed in intermittent strokes. At the end of the upward movement, the end of the agitator was just above the lowest row of tuyères.

A report on the tests which were conducted on Millers Creek, Pocahontas No. 3, Upper Freeport, and Pittsburgh coals has been prepared (14). Briefly, the results showed that with the agitator in operation a fire was maintained with fewer minutes of operation in each hour, less smoke was produced in off periods of operation, and satisfactory operation without attention was obtained with coals that, without the agitator in operation or with conventional stokers, were difficult to burn. For example, a fire was satisfactorily maintained with 0 × 3/4-in. Upper Freeport slack for a week, during the greater part of which the stoker was operated for only a few minutes in each hour to maintain a fire. When burning the same size coal in this or another typical stoker without an agitating device, the fire would go out. Removing particles smaller than 1/4 in. was necessary to obtain satisfactory operation on the normal stoker but that with the agitator maintained an entirely satisfactory fire for 3 1/2 days with operation for 4 min in each hour even with the 0 × 1/4 in. slack that had been removed from the coal. The trial was then ended because of the desire to start another test.

Fig. 1 shows the type of fuel bed obtained with a moderately strongly coking 0 × 3/4-in. Pittsburgh coal without and with the agitator. Differences in the type of fuel bed and absence

FIG. 2 SIMILAR VIEWS WHEN BURNING STRONGLY COKING UPPER FREEPORT COAL
(The bed at the left is $^1/_4 \times {}^3/_4$-in. coal without the agitator; that at the right is $0 \times {}^1/_4$-in. coal with the agitator.)

of coke trees with the agitator are clearly seen. The left half of Fig. 2 shows the type of fuel bed obtained with the Upper Freeport $^1/_4 \times {}^3/_4$-in. coal in a conventional stoker. Although it burned fairly satisfactorily in this size the masses of coke were large and clinker removal was difficult. The right half shows the fuel bed obtained with the agitator in operation after the $0 \times {}^1/_4$-in. Upper Freeport slack had been burned under hold-fire conditions for three days. A small coke tree is visible but it was much less massive than without the agitator in operation and caused no difficulty.

Difficulty from burning the end of the agitator might have been expected as it may be left at its uppermost position when the stoker shuts off. Even with the free-burning Millers Creek coal which burns with a thin fuel bed, no signs of metal oxidation were visible. Measurements of temperatures within the fuel bed of a stoker which were made later show that temperatures within this zone are well within the safe limit for steel. Other methods for obtaining agitation of the fuel bed or accomplishing a similar result will undoubtedly be developed by stoker manufacturers and the stoker made universal in its application to coal.

Present-type stokers in which the ash is removed as clinker at intervals by hand is not completely automatic but it fills a distinct need both in homes of that economic class where a houseman is available for attention to the fire and in homes of the class where this small amount of attention is not considered excessive. Another large class of homes demands completely automatic heat and stokers for all bituminous coals which remove the ash automatically must be developed. It is reasonably certain that this will come in the relatively near future.

THE LARGE STOKER

Two principal problems in burning coal on the single- and double-retort and the multiple-retort underfeed stokers are coking or matting and clinkering or slagging. Removal of ash from the single- and double-retort stokers is still largely a manual operation, by pulling the clinkered and loose ash from the dead plates or by dropping the dump plates at the side. It is not only backbreaking work for a fireman but results in inefficient operation and decreased capacity while it is being done. More automatic means for removal of ash from these stokers is highly to be desired.

Tobey's paper (2) states that the multiple-retort stoker consists of several single-retort stokers placed side-by-side. With all respect for the ingenuity and thought that has made the large underfeed stoker as satisfactory and efficient a combustion device as it is today, one cannot escape the impression that the stoker, like Topsy, "just growed." Coal in one of these stokers travels upward from the retorts and laterally across the tuyères until it meets fuel from the adjacent retort and the two streams then receive a component of force downward along the stoker. When one considers that combustion occurs over the entire length of the stoker and ash released at any point must travel over the entire remaining length of the fuel bed before it reaches the dump or clinker grinder and is heated, cooled, reheated, and mixed with other ash, there is little wonder that the ash is fused to a clinker, blows out of the fuel bed to deposit on the walls or tubes, or sometimes runs to the tuyères, stops them up, and causes burning of stoker iron.

Traveling-grate stokers have a much more logical system of ash disposal by which it is moved along and away from the area of intense combustion without agitation. The suggestion may be ventured that an opportunity exists for combining the underfeeding of the coal for combustion of the volatile matter with overfeeding like the traveling grate for combustion of the resultant coke.

In the transition zone positive means of agitation to insure breakage of the coke masses to the proper size for rapid combustion would have to be applied. Even on the present type of underfeed stoker, some modification of the positive agitation that has been successfully applied to the small underfeed stoker should be helpful in elimination of matting difficulties and consequent nonuniform burning.

The underfeed stoker has grown in length and width with a corresponding increase in burning capacity with little knowledge of the fundamentals of the combustion process within the fuel bed. Nicholls and Eilers (8) and Mayers (9), whose work was previously mentioned, gave the first insight into the process. In an attempt to learn more of what goes on in practical fuel beds, rather than the ideal ones used by Nicholls, Battelle Memorial Institute has been conducting a study of the combustion process in the small-stoker fuel bed. This work is now being extended in cooperation with the Coal Research Laboratory of Carnegie Institute of Technology to the study of conditions in the fuel bed of a large underfeed stoker at the Hell Gate Station of the Consolidated Edison Company of New York, Inc.

Dillon and Engle (15) conducted a survey a few years ago which showed that the average cost of stoker iron is 6 cents per ton of coal. If we assume that 40,000,000 tons of coal are burned annually on underfeed stokers, $2,400,000 is being spent for stoker iron. This amount should be reduced. Water-cooling of stokers has been successfully applied as described by Bennett and Herbeck (16) but this means extensive revamping.

Application of metallurgical research to this problem should result in a type of casting that would give a much longer life and a lower cost per ton of coal.

SPREADER STOKERS AND PULVERIZED COAL

Spreader stokers and pulverized-coal burners are considered together in this discussion of the future for, although they have problems in relation to the characteristics of coal which are common to other types of burning equipment, they have the common problem of fly ash. This problem is not unique with these two for the discharge of fly ash can be serious with other burning equipment but is outstanding with these two types. This problem will grow more serious as the number of these installations grows and as the public becomes more and more conscious of the air-pollution problem.

Some decrease in the quantity of fly ash from pulverized coal can be obtained by using the slagging principle of ash removal but the decrease is not great. At present, the remedy seems to lie in the direction of the dust arrester and favorable progress is being made in their development along several different lines. Improvements to make them less space-consuming, more efficient, and lower in cost are greatly needed so that they will be applied as a matter of course not only to the large industrial or utility installations but also to the small ones.

CONCLUSION

The answer to the coal-selection problem that has been given in this paper has consisted of two phases, (*a*) research and (*b*) education. The burden of research in utilizing bituminous coal has, until recently, rested almost entirely upon large users of coal, manufacturers of burning equipment, universities, and the government. A few large producers have conducted research upon their own coals but no general program on bituminous coal has had the producers' support. Now, however, the industry is supporting research and education on coal utilization. Appalachian Coals, Inc., has conducted a series of meetings under the direction of J. E. Tobey, manager of the fuel-engineering division, in the last three years which are outstanding in the quality of the papers and the discussions. They are not confined to members of that group and every one is welcome to attend. The papers and discussions have greatly widened the knowledge of those who have attended and copies of the Proceedings have had wide distribution among coal producers and users and equipment manufacturers. The National Coal Association has had since last year an engineering department at whose head is C. A. Reed with long experience as a user, manufacturer, and producer. Education is the principal work of this department.

For two and a half years, the research organization of the bituminous-coal industry, Bituminous Coal Research, Inc., has been active in a program of research, some of whose results have been mentioned in this paper. In addition to the varied phases of research on small and large underfeed stokers, an extensive program of research on the treatment of coal with oil to allay dust is being carried on in cooperation with the Standard Oil Company (New Jersey), Sun Oil Company, and The Viking Manufacturing Co. These investigations are being made at Battelle Memorial Institute. Looking toward the future, a program of research on hydrogenation of coal is sponsored at Pennsylvania State College.

The coal industry is, therefore, now taking its proper place in the picture and continued cooperation from the industry may be expected. Combined efforts of producer and user and the equipment manufacturer can solve their common problems. In closing, it is urged that these efforts be directed not so much at large installations but small and average ones. The closing sentences of the last paper (17) that the late O. P. Hood gave before the Society are in order here. They were:

> The general plane of understanding of fuel problems is rapidly rising. One hundred years ago there was no such thing as a boiler plant running at 90 per cent efficiency. We have such cases now. But to produce any considerable effect in the elimination of waste of fuels, we must look to improved average practice rather than to our few best records. There is evidence that all of our fuels are being used more rationally each year and that the average man, and woman too, knows more and cares more about fuels.

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ADAPTING GAS ENGINES *to* SEWAGE-SLUDGE GAS

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TO GAIN a proper conception of the place that the gas engine occupies in sewage-treatment practice, we must first understand a few fundamental principles underlying the modern science of human-waste disposal. A little thought will tell us that nature long ago perfected her own sewage-treatment plant, and we must adapt her ways to our use.

Any complex, organic material deposited on land or in water will be attacked by nature's forces, and in due time will be either oxidized or reduced to more elemental compounds. If subjected to free and continuous action of the air, organic matter is attacked by aerobic organisms and is oxidized, but if decomposition proceeds in the absence of oxygen, or anaerobically, destruction is putrefactive. In putrefactive, anaerobic decomposition of organic matter, the more volatile portions are gasified, and the gases thus liberated are of diverse kind and character. Their exact nature depends partially upon the kind of material being decomposed and partially upon the environmental conditions surrounding the decomposition. In general, we find two gases predominating, carbon dioxide and methane. If the reaction proceeds on the acid side of neutrality, carbon dioxide predominates, but if the reaction is slightly alkaline, methane predominates.

With this nature lesson as a textbook, the sanitary engineer has learned to control the decomposition of sewage solids, and lately he has produced useful power from the gases liberated in one phase of human-waste disposal. Thus we come to the proposition that a sewage-treatment plant is a natural-gas well with no royalties charged for its development. Whether or not the power potentially available from this gas may economically be harnessed is a question that can be answered only after a collaboration of sanitary and mechanical-engineering skill.

About six years ago, I convinced myself that the Springfield Sanitary District was wasting valuable fuel at the sewage-treatment plant and proceeded to determine how it might be made to perform useful service. My then feeble knowledge of thermodynamics led me into several blind alleys of thought but thanks to the able assistance given by the engineers of several gas-engine builders, notably Worthington, Cooper-Bessemer, Ingersoll-Rand, and Clark, I finally made an installation that has proved to be a financial success. Subsequently gas engines have been installed at nearly fifty sewage-treatment plants in America. While this particular market for gas engines and auxiliary and complementary equipment may at first appear to be limited, it has nevertheless been of interest to several companies. Among the more important American installations are engines totaling 1200 hp at Washington, D. C., 900 hp at Coney Island, N. Y., 835 hp at Peoria, Ill., 600 hp at Los Angeles, Calif., 360 hp at Topeka, Kan., 335 hp at Springfield, Ill., 300 hp at Durham, N. C., and 300 hp at Cedar Rapids, Iowa. These units, together with the many of smaller capacity, indicate a potential market of considerable importance.

As indicated in the beginning, a sewage-treatment plant does nothing more than speed up the tempo of natural forces. In the type of plant where usable gas is evolved, the solid matter removed from the sewage is pumped into deep tanks and forced to undergo anaerobic fermentation. Bacteria and other organisms feed upon the organic matter, partially liquefying it and partially gasifying it. We trap the gas under domes, store it under a gravity holder, feed it to an engine, and behold, sewage is made to work for us!

CHARACTER OF SEWAGE AFFECTS GAS PRODUCTION

Since the gas comes from the decomposed or digested portion of the volatile solids, the weight of gas available is a direct function of and substantially equivalent to the weight of volatile matter digested in the tanks. As a practical matter, from a well-operated plant in which the sewage is given what is known as "complete treatment," one might expect to recover an average of 0.8 cu ft per day from each person served by the tributary sewers. This figure represents merely a fair average and is approximately accurate only when considering human sewage. Certain industries, such as breweries, packing houses, corn-products plants, and the like, may deliver such quantities of organic matter to the sewers as to increase the average gas yield tenfold. When household and hotel garbage is ground and dumped into the sewers, the resultant gas may reach a total of 2 cu ft per capita per day. Peoria, Ill., is cited as a good example of the effect of certain industrial wastes upon gas production. The sewage-treatment plant there serves 110,000 people as well as several industries that deliver strong organic wastes. Sewage-sludge gas is sufficient not only to keep two 835-hp engines running continuously, but a quarter million cubic feet of excess gas is wasted daily.

TABLE 1 APPROXIMATE COMPOSITION OF SEWAGE-SLUDGE GAS

Constituent	Percentage by volume
Methane	65
Carbon dioxide	30
Hydrogen	2
Nitrogen	3
Oxygen	Trace
Carbon monoxide	Trace
Hydrogen sulphide	Trace

Unfortunately the production of gas does not proceed at a uniform daily rate, the maximum yield often being three times the minimum. This naturally has a profound effect upon the use to which the gas may safely be put. However, with properly heated tanks and particularly at plants having several digestion tanks, the severity of the daily fluctuations has been greatly alleviated. Topeka, Kan., has smoothed the operation of the engines by augmenting the supply from a natural-gas line during periods of minimum production. In April, May, and

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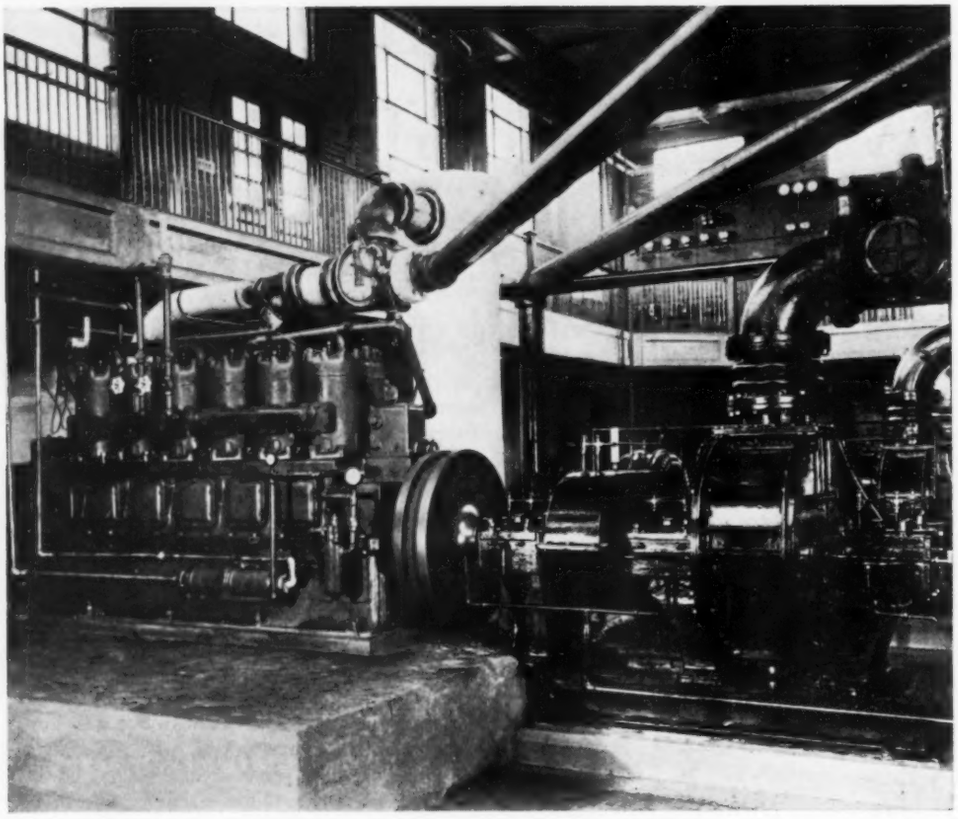

FIG. 1 CLARK ENGINE DRIVING A CONNERSVILLE BLOWER

June of this year, the engines used 7,605,000 cu ft of sludge gas, but only 106,000 cu ft of natural gas.

In general—gas coming from anaerobic digestion of sewage sludge is a mixture having approximately the composition given in Table 1. Hydrogen sulphide, although almost always present, is rarely found in concentrations exceeding 0.1 per cent by volume except in communities served by sulphureted waters or where domestic sewage is mixed with industrial wastes containing sulphur.

From the foregoing discussion, one might expect an average, well-operated sewage-treatment plant to produce gas containing approximately 500 Btu per day per inhabitant. Consequently it appears safe to consider that the daily sewage from twenty humans is potentially capable of producing gas which, when used to run a gas engine under optimum conditions, will develop 1 bhp-hr, or in other words, the daily sewage from 480 persons is sufficient to develop 1 bhp continuously. According to these figures, Springfield, Ill., a community of 72,000, should be able to keep a 150 hp unit running. It does, except for minor shutdowns, and sometimes two units are running, with a maximum of 335 bhp.

That such crude, rule-of-thumb measures are employed to gage the power available at any given plant must not be inferred. On the contrary, the engineer has to analyze the problem from the standpoint of the sewage flow, chemical composition, type of treatment, and efficiency of solids removal and digestion. After determining the available gas, selection of engine size and type of power development will be governed by recognized principles of sound engineering practice.

HEAT TRANSFER TO DIGESTION TANKS

A discussion of some of the work done at the Springfield plant will serve as a basis from which to point out some of the practical and theoretical problems incidental to the use of sewage-sludge gas for power. Without adequate training in mechanical engineering, I nevertheless felt obliged to undertake a series of experiments. Results of this work and conclusions drawn therefrom, while not necessarily precise, have so far proved to be sufficiently accurate.

I wanted to do two things simultaneously, use the gas as fuel in an internal-combustion engine and salvage as much waste heat as possible to keep the digestion tanks up to 90 F in the winter. The engine is cooled by circulating water, which, after leaving the water jacket, passes through an exhaust-gas heater. From this heater it passes through coils around the several digestion tanks, and the heat is lost before the water returns to the engine in the closed system. My first problem was to determine the coefficient of heat transfer from the coils to the viscous sludge in the tanks. A series of careful tests revealed that in heavy sludge, containing twelve per cent of solids, galvanized-iron coils transmit only 10.2 Btu per sq ft per hr per 1 F differential. Thinner and less viscous sludges around the coils gave higher coefficients, the maximum being 39.0 in the upper layers containing about 2 per cent of solids. Since I proposed to install several rows of coils covering about 7 ft of tank depth, I felt safe in adopting an average coefficient of 15.0 as applicable to the entire heating surface.

Our plant records gave the volume and temperature of the sludge added to the tanks, and by further experiment I learned how much heat was dissipated through the tank walls and cover. With this information at hand, I determined that the heat required to bring the sludge to tank temperature and the tank losses were sufficient to absorb the engine-jacket and exhaust-gas heat in cold weather. By wasting the latter in the warmer months, the engines can be cooled without using fans or a cooling tower.

Calculating the proper size of engine presented a theoretical problem which did not bother the engine companies as much

as it did me. Our gas analyses indicated the presence of only 65 per cent of methane, giving rise to the belief that an engine using the gas could not safely be rated as highly as one burning pure methane. Given an engine fueled with methane and having a compression ratio of 6 to 1 with total volume of 1.2 cu ft, and assuming perfect combustion with an air-methane ratio of 10 to 1, at each suction stroke the cylinder will admit 90.9 Btu. This presupposes that the purging stroke leaves the cylinder head full of inert gas. The same engine burning our sludge gas can admit only 86.6 Btu. Therefore a 6-to-1 ratio engine burning sewage-sludge gas should be derated about five per cent. Engines with smaller compression ratios should be still further derated.

RESULTS OBTAINED IN OPERATION

Our first power installation comprised a Z-6 Clark engine driving an existing Connersville blower, a Davis-Paracoil exhaust-gas heater, a 23,000-cu ft gas holder, and an additional gas-collection dome. Subsequently we installed a Worthington CG-3 engine and an Edgemoor exhaust-gas heater. This engine drives both a generator and a Connersville blower. Prior to installing the Worthington engine, the generator was used as a synchronous motor to drive the air blower. The two installations are shown in Figs. 1 and 2. Before the first engine was installed we made tests to determine the brake horsepower required to drive the blower under varying conditions. Consequently we had an accurately calibrated dynamometer with which to test engine operation. Our later experiments gave some interesting results.

As soon as the engine was in place we tried to find the best setting for the air-intake shutter so that for constant-pressure loading we might obtain and keep the optimum air-fuel ratio. Since the engine was initially designed and adjusted for operation with methane, we were not surprised to find that the air intake had to be partially closed. However, we were surprised to learn how greatly the air-fuel ratio affected the brake efficiency of the engine. Determining the proper spark advance for correct operation with sewage-sludge gas was more difficult. When installed the spark was set at 10 deg in advance of top dead center, but by successive tests we found that 23 deg gave the best operating results. Inasmuch as the gas contains about 35 per cent by volume of carbon dioxide and nitrogen, to suppose that its rate of flame propagation is slower than for pure methane appears reasonable. Naturally, I recognize that the degree of spark advance should also be correlated with both speed and compression ratio.

My previous theoretical calculations with regard to derating a sewage-sludge-gas engine were partially verified by test. At about 67 lb brake mean effective pressure, the engine begins to lose speed slightly; at 69 lb the speed drops off about two per cent, and at 70 lb it drops $3^1/_2$ per cent. While this refers only to one engine with constant torque loading, I feel that until we obtain more adequate data, the rating should be kept under 70 lb brake mean effective pressure.

Experience has shown that sewage-sludge gas can be used safely in engines with compression ratios of 6 to 1. Two such engines at Springfield have been running for several years, and two at Peoria, Ill., and two at Topeka, Kan., likewise operate successfully at that ratio. When first installed, the Clark engine ratio was 4.5 to 1 but with it we were not able to obtain a brake efficiency test higher than 23 per cent. The Clark Engine Company furnished new cylinder heads giving a 6 to 1

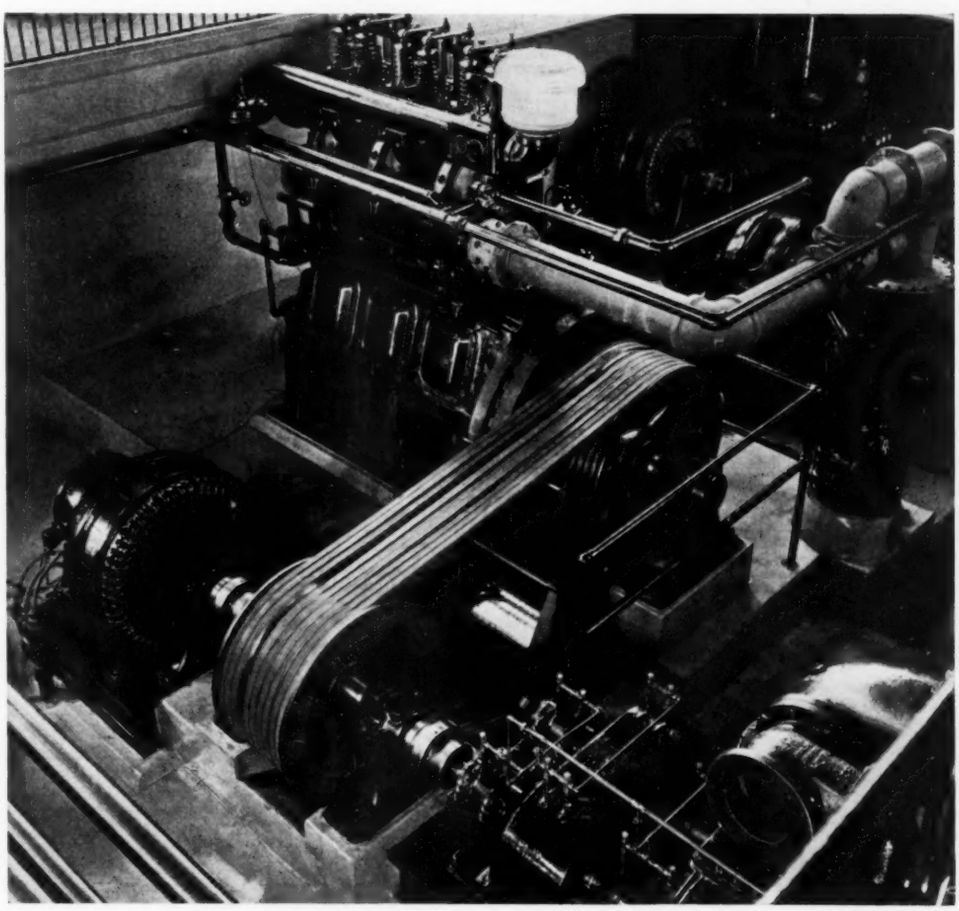

FIG. 2 WORTHINGTON ENGINE DRIVING AN ELECTRIC GENERATOR AND A BLOWER

ratio and guaranteed the engine against failure caused by the resultant increased pressures. With the higher compression, we have had no difficulty obtaining a fuel consumption of 10,000 Btu per bhp-hr when running under full load. In this connection it may be interesting to study Fig. 3 which gives the fuel consumption under varying loads. As the Worthington engine drives both an air blower and a generator through belts, our experimental data for that engine are not so accurate as for the Clark, but we have tested it several times and found fuel consumptions under 10,000 Btu per bhp-hr at full load. While I am thus certain that sewage-sludge gas may be used safely and efficiently with compressions as high as 6 to 1, my confident although unproved belief is that higher ratios may be used without fear of detonation. This belief is based upon the probable dampening effect of the initial carbon-dioxide content of the gas.

IGNITION SYSTEM GAVE THE GREATEST TROUBLE

Considering all our operating difficulties of whatever nature, the large majority are attributable to the ignition system. Here again I feel that carbon dioxide in the gas is largely to blame, although sulphur corrosion of the points and coils may be the cause. We keep a spare magneto in perfect running condition at all times and make a quick change whenever the engine starts to run unevenly. In this connection twin ignition is essential to good operating results.

Sewage-sludge gas, trapped over the digestion tanks, contains small quantities of finely divided impurities which will be drawn into the mixing valve unless moisture in the gas is precipitated by chilling ahead of the engine. To accomplish this, the gas line from the holder should be built underground and laid so as to drain uniformly downhill to a drip pot located below the engine grade. If this is done and particularly if the gas velocity is not too high, entrained organic matter is easily removed.

I have heard considerable discussion but only little worthwhile information relative to the effect of hydrogen sulphide upon gas engines. We have run one engine almost constantly for four and one-half years and a second engine for two years and can find no evidence of trouble which is definitely traceable to hydrogen sulphide. Spark plugs last upward of three months, but magneto points show sulphur corrosion caused by presence of the gas in small quantities around the engine and have to be cleaned every week. Bronze valves quickly turn greenish blue after being polished. To date we have not had to renew a single bearing or make any bearing adjustments. We take the engines down after about nine months of use, clean the piston rings, grind the valves, polish the bearings, and wash the oil sump and filter. Except for a reddish tinge, the tops of the pistons and the cylinder heads are free from deposits. The intake valves show little evidence of pitting, although the exhaust valves and seat inserts are invariably pitted. In four and one-half years we have replaced only four piston rings and four exhaust valves on the six-cylinder Clark engine, and in two years the Worthington engine has required no ring or valve replacements. Of course we do not have high concentrations of hydrogen sulphide in our gas, rarely exceeding 0.1 per cent by volume, but if it were present in objectionable percentages, we should pass it through an iron-oxide scrubber and eliminate the difficulty.

We cannot give conclusive data on lubricating-oil consumption. In 1936, the engines used 660 gal and compressed 1893 million cu ft of air. Under certain test conditions the blowers required 700 bhp-hr to compress 1 million cu ft of air, which indicates that the engines produced 1,325,100 bhp-hr exclusive of the generation of about 50,000 kwhr of current, or energy requiring the application of about 76,000 hp-hr. A total of 1,401,000 bhp-hr developed with the use of 660 gal of lubricants indicates that we used one gal for each 2120 delivered horsepower-hours. To date we have not used an oil centrifuge but expect to do so before long. Only three analyses have been made of used oil in the crankcase, these indicating no unusual degree of contamination and no trouble from sulphur. These figures are subject to some error because we have no means of determining the average air pressure at the blowers and cannot compute the delivered horsepower accurately without knowing the pressure.

AVERAGE HEAT RECOVERY IS APPROXIMATELY 75 PER CENT

We conducted tests to determine not only the best operating conditions but also the heat recovered from the water jacket and exhaust gas. At a sewage-treatment plant where sludge is digested in separate tanks, the need for low-grade heat is constant. Therefore we salvage all the heat that we possibly can. Our results are both gratifying and astounding. Under varying conditions of engine loading we recover from 21 to 26 per cent of the total heat value of the gas as useful work. From the water jacket we recover from 30 to 37 per cent of the total value, and from the exhaust gas we recover from 17 to 22 per cent. The maximum gross recovery recorded in any of our tests has been 81 per cent, with the average around 75. Before we installed the gas engines, we burned the gas under boilers to heat the tanks. Now, after utilizing the gas to its fullest extent for power, we still are able to heat the tanks in the

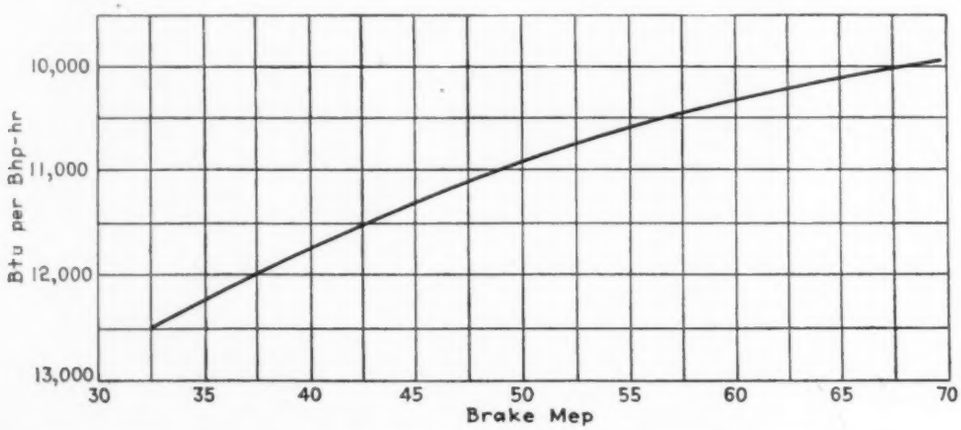

FIG. 3 FUEL CONSUMPTION OF THE CLARK ENGINE AT VARYING LOADS AND CONSTANT SPEED

severest winter conditions. To gain as high a temperature as possible in the digestion-tank heating coils, we circulate as little water as we can, allowing the temperature differential across the engine water jacket to reach 25 F.

A brief study of heat salvage brings out some interesting facts. If we circulate larger volumes of water at comparatively low temperature, the efficiency of engine cooling increases for two obvious reasons; first, turbulence is greater, and second, the temperature differential is higher. The same situation prevails in the exhaust-gas economizer, with a third factor entering, chilling of the exhaust gas with the opportunity to recover the latent heat of evaporation. Therefore, to salvage the greatest quantity of heat we should circulate as much water as we can, consistent with the allowable water-jacket pressures. However, if the temperature of the water reaching the digestion-tank coils is too low, we have to increase the square feet of heating surface. Consequently the economy resulting from the salvage of additional heat may be lost by having to install more coils.

We have abused the exhaust-gas boilers, particularly the Davis-Paracoil. During severe winter conditions we lower the final exhaust-gas temperature to as low as 180 F, with the result that water vapor is precipitated. With sulphur in the gas, sulphurous acid was formed, and we eventually ruined the fire tubes, but they were replaced at no great expense.

My calculations for gross heat recovery bring to mind a theoretical discrepancy. In computing engine efficiency, I used the "lower heating value" of the gas as recommended in standard gas-engine practice. However in calculating waste-heat recovery I should perhaps use the "higher heating value," since we are certainly cooling the exhaust far below the temperature it had when it left the engine. I have read results of tests by others on heat recovery and wonder how the writers compute their figures.

NET SAVINGS IN 5 YEARS TOTAL $41,155

Many people inquire whether or not the investment has been economically sound. Costs can be figured in so many ways that it is almost impossible to set up data in a manner suitable to every one. The fact must be borne in mind that I installed the engines in a sewage-treatment plant to meet conditions prevailing there. Our labor of attendance has actually cost us nothing beyond what we would have paid if the engines had not been installed. Neverthless, I have charged the labor of attendance against the engines. Since we are a municipal corporation, we pay no taxes. We formerly carried no insurance on the equipment but recently covered the engines against fire and damage from explosion. This insurance costs $24 per annum. Table 2 gives a summary of annual charges from Jan. 1, 1933, until July 1, 1935, when only one engine was in service and Table 3 shows the charges from July 1, 1935, until Jan 1, 1938, the latter being extended from our records as of July 1, 1937.

TABLE 2 ANNUAL CHARGES—JAN. 1, 1933, TO JULY 1, 1935

Interest	$15,735	@ 0.045	$ 708.00
Depreciation	15,735	@ 0.0481	759.00
Lubricating oil	400 gal	@ $0.41	164.00
Labor	38 man-days	@ $4.00	152.00
	15 man-days	@ $8.00	120.00
Repair parts			90.00
TOTAL			$1,993.00

We have no accurate means for determining the savings effected because more than ninety per cent of our engine power is used to drive blowers in direct connection. We have the monthly bills for purchased current before and after the power development, but they are somewhat unfair for the reason that we now use more power for all plant purposes than formerly, the increase being occasioned by the increased volume of sewage handled by our plant. However, the records show such an astounding drop in current costs for all plant purposes that we submit Table 4 as representing the gross savings.

TABLE 3 ANNUAL CHARGES—JULY 1, 1935, TO JAN. 1, 1938

Interest	$23,810	@ 0.045	$1,071.00
Depreciation	23,810	@ 0.481	1,145.00
Insurance			24.00
Lubricating oil	660 gal	@ $0.36	238.00
Labor	54 days	@ $4.00	216.00
	18 days	@ $8.00	144.00
Repair parts			111.00
TOTAL			$2,049.00

TABLE 4 GROSS SAVINGS

Calendar year	Compressed air produced by gas engines, per cent	Annual cost of all purchased power	Decrease in cost of current[c]
1932[a]	0.00	$13,320.00	$ 0.00
1933	52.20	6,490.00	6,830.00
1934	82.50	4,140.00	9,280.00
1935	85.20	3,750.00	9,570.00
1936	97.90	2,150.00	11,170.00
1937[b]	99.50	1,420.00	11,900.00

[a] Prior to installation of gas engines.
[b] Forecast made July 1, 1937.
[c] Decrease made in current at 9 mills per kwhr.

From Table 2 we find that, exclusive of depreciation, we paid out $3085 for interest and operation in the first two and one-half years. Table 3 shows a comparable expenditure of $4510 for the second period of two and one-half years, indicating a total of $7595 for the five-year period. From Table 4 we find that the gross reduction in electric bills amounts to $48,750 for the same five years or a net of $41,155 above interest and operating charges. At the close of 1935 we had paid back substantially the entire capital investment and still had the equipment in good condition. Consequently we feel satisfied that for our particular needs the investment was sound. Of course, every situation is different and requires different handling.

In closing I have only to say that in recommending an engine for the development of power at a sewage-treatment plant, one should remember that the engine may not receive skilled maintenance. Consequently it must be designed to stand abuse, run long hours without attention, and perform when other equipment fails. This automatically turns our attention to low rotative speeds, ultraconservative ratings, and heavy parts, particularly shafts and bearings. In other words, the engine should be the best that money can purchase, not something cheap that will just get by.

ADDING activated carbon to fresh sludge in sewage digesters reduced the odor, raised the methane content of the gas produced, improved the drainability of the sludge, and increased its temperature when not more than 5 ppm was added. At 20 C, the addition of between 5 and 15 ppm apparently increased the gas yield and hastened complete digestion but had the opposite effect on both at 28 C. Greater additions at 20 C reduced the gas yield but gave increased drainability, the maximum being reached when 30 ppm was added.—*The Engineer*, Sept. 24, 1937, p. 337.

Status of the

EMMET MERCURY-VAPOR PROCESS

By W. L. R. EMMET

GENERAL ELECTRIC COMPANY SCHENECTADY, N. Y.

I PERHAPS ought to excuse myself for appearing before this Society at my age to advocate something new in engineering.

The work of which I intend to speak is being carried on by the General Electric Company and I have been retired from their service for about seven years. Such original work and experimentation as I have been able to carry on has been done in somewhat indirect association with the General Electric Company's turbine department and has, not unnaturally, been subject to some delay and misunderstanding.

My inventions in connection with this mercury system will presumably be developed and used by the General Electric Company and, while I think I have a pretty good understanding of the aims, I cannot speak positively for the company or be sure that the opinions which I will express are fully shared by persons in authority in that corporation.

I have been assuming and bearing heavy responsibilities in new departures in engineering for more than fifty years and have been successful in practically all of them. The one possible exception in this record is the mercury-vapor process which, after many years of effort, I still consider unfinished. Fifteen years ago at a meeting of this society in Cleveland, I presented a paper[1] on the subject of the mercury-vapor process which I had first invented and worked on many years earlier. This paper is the only important public utterance which I have made on this subject. The reason for this silence is that there has been only one brief interval in which I have considered that this process was ready for commercial exploitation.

The mercury installation made at Hartford about ten years ago was made for commercial use and intended as a first step in that direction, but soon after it started I began to perceive that much more must be learned before it would be expedient to try to introduce the process on a large scale.

This plant was first started in 1928 and since that time has been actually running in regular service most of the time. In 1932 it was shut down for some time for retubing, tubes of the same size and shape but of a little better construction being substituted for those originally installed. Since this retubing, the plant has been run about 7000 hours in each of the six years that have elapsed.

In all of this service there have been no appreciable troubles outside of the mercury boiler, and all other parts, although very radically different from anything which had been built before, are running today just as they were originally made.

Since this plant has shown a fuel economy far better than that of any steam plant, it might presumably be considered a proper basis for extended commercial undertakings. I, however, have not so considered it, except for one short period.

This plant at Hartford gives 10,000 kw from the mercury turbine, and, with the steam which it makes used to the best advantage, will give a fuel rate of about 10,000 Btu per kwhr.

Since the Hartford plant was started, two large mercury installations have been made, each about twice the capacity of that at Hartford. Outside of the original studies on which the designs of these plants were based, I have had little to do with these installations. They have to date been generally less successful than the plant at Hartford, but have been labored with by the turbine people in Schenectady with an admirable courage and persistence, and lately these efforts have begun to bear fruit of an encouraging nature.

Since my retirement such efforts as I have been able to give to the mercury process have been devoted to attempts to develop by experiment a kind of mercury boiler which would overcome the defects which I saw in that at Hartford. These defects can be stated in two words—cost and inaccessibility, the latter word relating to difficulty in cleaning of the heating surface, not only inside where stoppages of small inaccessible passages may occur, but outside where under some conditions ash accumulations might be troublesome.

This work of mine has related to a type of mercury boiler of which I have had the idea for a long time. I will not try to give any idea of this here. I have done so in a paper which will be presented at the naval architects' meeting next month. It is enough to say that a boiler of this type is in operation in a small installation at the General Electric Company's Pittsfield works. Its performances have convinced me that its objects have been accomplished, and that even if we had gained no more new knowledge within recent years, the mercury process could easily and successfully be commercialized for many important purposes.

This is true because the design of this boiler is such that while it is made for a capacity from mercury and steam of only about 2500 kw, it is designed so that it can be used in groups of similar units up to any desired capacity.

Without departing from the conditions shown to be practicable, much larger units could be made with equal certainty of success, and the principles demonstrated can presumably be used in a variety of ways.

So much for my work, but this is not all. Experiments have been going on for some years in the General Electric research laboratory on metals which can be alloyed with mercury to improve its action in boilers.

The indications are that, owing to these discoveries, we may be able to use higher pressures in mercury boilers than were formerly thought practicable, also to avoid dirt troubles and greatly to improve the heat-transfer conditions.

Other valuable knowledge and experience have been gained through the efforts of others, as has been said, and entirely apart from mine. As a consequence, I now, for the first, time feel sure that the process, with which I have worked and worried for so long, is in condition to enrich the world in almost every kind of activity where power is made from fuel.

Prepared text on which was based an address delivered at a dinner, held at the Lawrence Hotel, Erie, Pa., Oct. 5, 1937, in connection with the National Fall Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[1] "The Emmet Mercuy-Vapor Process," by W. L. R. Emmet, Trans. A.S.M.E., vol. 46, 1925, pp. 253–285.

EDUCATION *and* BUSINESS LEADERSHIP

By KARL T. COMPTON

PRESIDENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.

I AM NOT an expert in the special subject of this conference, distribution, unless you include scientific and technical knowledge as among the commodities whose distribution is of value to business. I hope to show that this is true. In any case, however, the basic principles and operations of education and of business have much in common. For one thing, both depend on sources of raw material, a manufacturing or processing plant, and a marketing or distributing system through which manufactured products can be placed where a demand for them exists.

Our raw material is entering students. Every educational institution maintains an admissions staff to exercise a quality control of this raw material which is suited to its particular ideals and standards. Just as oil or mining companies send out prospectors, so most educational institutions have some recruiting system, usually based on alumni cooperation. Our manufacturing process is carried on in classrooms and laboratories by the instructing staff. Our distributing or selling operations are performed by an alumni placement bureau. It cooperates with the recruiting officers of business and industrial organizations who shop around among various educational institutions to secure for their companies the available graduates who are best suited to their particular needs.

COLLEGES AND BUSINESS ORGANIZATIONS ARE ANALOGOUS

Just as in industry, educational institutions can only operate on a stable basis if input of raw materials, processing operations, and disposal of the product are all geared together so that the flow sheet shows no bottlenecks, no failure in the supply of raw material, and no undue accumulation of goods on the shelf through overproduction, weakness of sales force, or obsolescence of the product. Similarly, like business organizations, educational institutions are subject to the same fundamental economic principles. We are governed by the law of supply and demand. We cannot operate for long on an unbalanced budget. We have our problems of labor hiring, firing, pensions, employee benefits, and the like, and a national professors' union which fortunately is operated on a high plane to safeguard against abuses and not to chisel for higher wages. We are vitally dependent on the maintaining of good public relations. We also are subject to the laws of the land and have our problems with government regulations, happily for us not as difficult as yours but nevertheless requiring attention.

Not all our institutions of higher learning are of the same type. Just as in the retail business, we have department stores of learning and educational specialty shops. I should probably never survive it if I should attempt publicly to classify educational institutions by their retail-store analogies, but you may try this for your own amusement. To help you get started, I will say that I classify the Massachusetts Institute of Technology as a specialty shop. And if you are well acquainted with colleges you will recognize not only department stores, but also mail-order houses, five-and-ten stores, the beginnings of a chain-store system in education, and perhaps even pawnshops.

This line of analogies could be pursued farther, but I would point out that colleges and universities are themselves in the class of business enterprises of direct financial importance in the community. Buildings and equipment in New England are valued at about $170,000,000, nearly all of which has gone into materials and wages in the building and machinery trades. These colleges spend approximately $45,000,000 annually in their operations and their students spend annually about $50,000,000 more, as a rough approximation. Thus the college business distributes annually nearly $100,000,000 in New England. I do not know just how much of this is money brought *into* New England from the outside; in Harvard, Massachusetts Institute of Technology, and several other institutions I would judge that about half the combined institutional and students' funds come from outside New England; in state universities the proportion would be much less. However, it is clear that the colleges are an important source of monetary benefit to New England and that it is a good community investment to maintain them in such conditions of excellence that their prestige will continue to attract students and benefactions.

This direct monetary value to the community is only a by-product of education. Before discussing this main and most important job of education, however, let me mention one other by-product.

Wherever is gathered together a staff of teachers competent to give training and instruction of a high quality in the college and university grades, there will inevitably appear an activity in research and production, be it in science, or in the professions, or in the fine arts. Such activity is one of the normal instincts of any person who is a live student of his subject. It not only makes him a better teacher but also creates an atmosphere and supplies ideas and problems which have an important rôle in the development of his pupils.

The significance to business of this work of educational institutions could be elaborated at great length, but I shall only suggest a few illustrations. You all know

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Address at a luncheon held in connection with a conference on distribution, Boston, Mass., Sept. 21, 1937.

the importance and vigor of chemical industry today. In his presidential address before the American Chemical Society a couple of years ago, Dr. Roger Adams, who is consulting chemist for several of our most important chemical manufacturing companies, stated that 95 per cent of the present chemical industry was based on discoveries made in university laboratories.

UNIVERSITY RESEARCH AN IMPORTANT CONTRIBUTION TO INDUSTRY

With a somewhat smaller figure, the same thing can be said of the electrical industry. A few years ago the National Academy of Sciences pointed out, in a pamphlet, that the modern steel industry could not exist without every one of some ten discoveries made in university laboratories. The entire aluminum industry is based on a discovery by a professor in a small college. And so on, this list could be extended ad lib.

Such contributions to industry from university laboratories are not past history only; they are of continual occurrence. They are not always recognized at the moment, for scientific discovery precedes invention, and an experienced industrialist has stated the equation "from invention to the shipping car equals seven years." Nevertheless, no fact of business is more clearly proved by a hundred years of experience than that new knowledge today means new applications of this knowledge which will result in new industrial activity in the not far distant future.

I believe that university laboratories will continue to be great producers of revolutionary discoveries and of that knowledge of materials, forces, and phenomena of nature which is the basis of industrial-research operations. There is a logical reason to back up this belief, as well as the weight of experience. This reason is the greater freedom and range of interest which is characteristic of a university as compared with an industrial organization. For the latter is intellectually circumscribed by the scope of its particular business, and its thought and work are aimed at the solution of its own problems. This is a favorable situation for work to improve a product, find a new one, or cheapen a method of manufacture. It is not so favorable to the development of original and unexpected new ideas, for these almost always appear useless at first, mere intellectual curiosities, and few business organizations can afford the luxury of paying wages for pursuing undirected intellectual curiosities.

One of my friends has used the illumination industry as an example. If the engineers of such a concern, 100 years ago, had been asked to develop a better lamp, they would have studied oils, wicks, tallows, lamp chimneys, and the like. The board of directors would properly have clamped down on any appropriations for experiments on magnets, batteries, rare metals, or the queer phenomena of electromagnetic induction if, by chance, one of the engineers had developed a curiosity about these irrelevant matters. But out of these came the present great electric light and power industry. Some of our great industrial laboratories of today are liberal in their policies and produce splendid scientific work as well as engineering development. But the limitations that I have mentioned are always there to a greater or a lesser degree, usually greater.

Research, as a by-product of education, is a significant factor in industrial progress, and the universities thus play a peculiar rôle in business for which no adequate substitute exists or has ever been seriously contemplated. I do not wish to belittle the rôle of industrial laboratories, for I have tremendous admiration for the work that many of them are doing. With the great technical progress that is made by industry and the high-pressure advertising that accompanies it, I think there is a popular tendency to forget or underestimate the importance of the university laboratory as a business asset.

EDUCATION'S CONTRIBUTION TO BUSINESS LEADERSHIP

Turning away now from the by-products of education to its chief purpose and product, I assert that the job of education is to educate, to impart or induce in young men and women the qualities of knowledge, intellectual power, special skills, and good character. To whatever extent these qualities can be developed by education and to whatever degree they are attributes of business leadership, in that measure is education a factor in business leadership.

If we attempt to assay the value of education to business leadership, we encounter many difficulties. How can we separate the effect of education from such other influences as native ability, luck, or inherited wealth in estimating the causes of success? And what is education, anyway? For many a self-taught man, or one who has learned by intelligent study of his own environment and experiences, is far better educated than many a university Ph.D. To be specific in my remarks, I shall limit my considerations only to formal education, especially in the college and professional-school grades.

With this understanding, one way to evaluate the contribution of education to business leadership is to examine statistically the backgrounds of present-day business leaders. In that particular branch of business designated as industry, as distinguished from finance or distribution, such a statistical study can be made by using census figures combined with a survey of American industry made by Dr. R. H. Spahr, director of instruction and curricula at the General Motors Institute of Technology. Taking from the census figures the fact that 5 per cent of our male population between the ages of 27 and 67 have had a college education, and from reports of the Office of Education

that about 13 per cent of college men attended engineering or technical colleges, and using Dr. Spahr's data on the 54,000 officers of about 500 typical industrial companies, the following facts emerge.

A college-trained man is 18 times as likely to be president of an industrial company as is a non-college man. He is 12.5 times as likely to be treasurer, twice as likely to be in charge of production, 18 times as likely to be an engineer, and 12 times as likely to be a sales official. Taking all these officers together the college man is seven times more likely than the non-college man to be one of them.

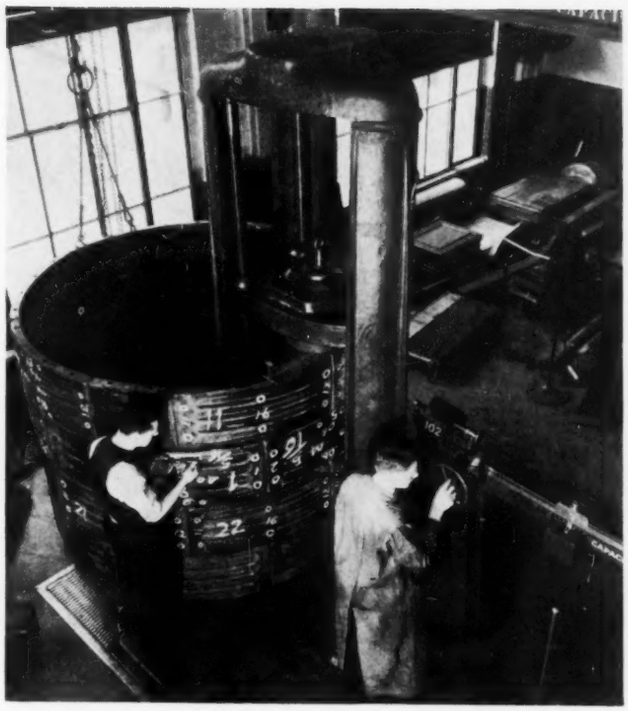
If we examine the influence of the type of college in which the education was secured, we find the following results which, at first glance, are decidedly startling. In one group we consider those who were educated at an engineering or technical college, and in the other group those who attended any other type of college such as liberal arts, law, business, and the like. Here we find that an engineering-college man is 12 times more likely to be found in the presidential position than if he had attended a nonengineering college. He is 5 times as likely to be treasurer, 30 times as likely to be in production, 174 times as likely to be in engineering, and 24 times as likely to be in sales. Grouping all offices together, an engineering-college graduate is 30 times as likely to find himself an officer in American industry as is a graduate of a nonengineering college.

This large factor in favor of the engineering colleges is, on second thought, not so startling after all, when we remember that industry is based largely on engineering and tends to attract engineering-school graduates. Undoubtedly, the proportions would be different if a similar study were made of the financial and distribution branches of business. Perhaps such studies have been made on a similar nationwide scale, but I do not know of them. Undoubtedly, many individual schools have made studies of their own alumni, as we have, in an attempt to evaluate the effectiveness of their own educational programs. We find, for example, that most of our mining-engineering graduates are doing well at occupations other than mining, graduates from our Department of Business and Engineering Administration progress rapidly in executive responsibility, and 70 per cent of the graduates of 14 years standing are now holding positions that involve some jurisdiction over the policies of their employing companies. While complicating uncertainties of interpretation are present, I believe that figures such as these must be accepted as evidence that the colleges of the country are making a significant contribution to business leadership.

PERSONAL CONTACT IMPORTANT IN DEVELOPING LEADERSHIP

I wish that time were available to discuss several directions in which attempts are now being made to improve educational processes, some of them with specific reference to developing powers of business leadership. I can only mention the one which seems to me to be the most interesting. It has been developed, tested, and put into regular operation at Massachusetts Institute of Technology under the leadership of Prof. E. H. Schell, who gave the first report on it before the International Management Congress in England last summer.

In earlier days, professional skill and attitude were transmitted from father to son or from master to apprentice. Some valuable features of this educational process have been largely lost in our modern formal education, which is more specialized in operation and has aspects of mass production. Professor Schell noted that our methods of training in medicine and law have retained the personal contact between master and apprentice in a powerful manner, whereas this is not done in training for the profession of business. The medical student has a



period of internship, where he comes in personal contact with the top men of the profession in their special fields. The young lawyer similarly starts his career as a sort of apprentice in an established law firm. The young man entering business, however, customarily starts out in contact only with the lowest grades of executive and the formative period of his life may have passed before he ever has an intimate opportunity to observe how an able executive handles his problems and what these problems are. Medicine and law are organized to help their novitiates; in business there is more of the attitude of "sink or swim," and "the devil take the hindmost." Notable exceptions, of course, can be found.

Schell's program involves supplementing the customary type of postgraduate work in business principles and practices with a skilfully arranged and frequent series of meetings at each of which a half-dozen or so of these students and a professor or two dine with a top executive of some business organization and then proceed to an informal discussion. The executive talks about any business problem that may be on his mind at the moment, or any aspect of his organization or methods, and then follows a period of question and discussion. Generally these discussions are still proceeding vigorously as midnight approaches. The executives get quite a kick out of the experience and, in the course of a year, the young men come really to have some little appreciation of the problems, policies, methods of thought, and operation of a variety of types of successful executive.

This plan has been in experimental operation for the past half-dozen years. I wish that time would permit me to give you the evidence of its success, as taken from the subsequent careers of the students themselves. At present, the chief aspect of the plan which is still in the experimental stage is the method of selecting the students, who must be college graduates with several years of subsequent experience in business. We are now trying to work out details of a plan whereby business and industrial companies will cooperate in helping us select young men whom they believe to show unusual promise of becoming leaders in their own organizations.

ANNUAL INCOMES *of* ENGINEERS

Sixth Series of Results of the Survey of the Engineering Profession Conducted by the U. S. Bureau of Labor Statistics

FIVE SUMMARY reports based on analyses made by the United States Bureau of Labor Statistics on returns from 52,589 engineers have already appeared.[1] The present article deals with sources of income in the engineering profession from 1929 to 1934 with which the sixth report[2] deals. From the introductory paragraphs of this report, in which the results are summarized, the following paragraphs have been taken.

Reports from 52,589 professional engineers to the Bureau of Labor Statistics, in its survey of the engineering profession, undertaken at the request of the American Engineering Council make it possible to relate the income data to nonengineering professional engineering activities. These data are probably the most comprehensive ever presented in regard to a professional group. The following general findings appear from analysis of the reports.

In 1929 the spread in the earnings of engineers engaged in nonengineering work was greater than in those obtained from engineering work. Thus, among engineers 40 to 47 years of age, 10 per cent of those engaged in nonengineering earned more than $12,424 and 10 per cent earned less than $2420 per year. The respective annual incomes of similar proportions of all those engaged in engineering work were $9615 and $2705; and of graduates in engineering $10,088 and $2936.

The age of maximum earning power for engineers arrives more quickly for nonengineering than for engineering work. At 48 to 55 years of age, however, those college graduates who stayed in engineering were doing as well as those who had gone into nonengineering work. This was true even at the highest income levels.

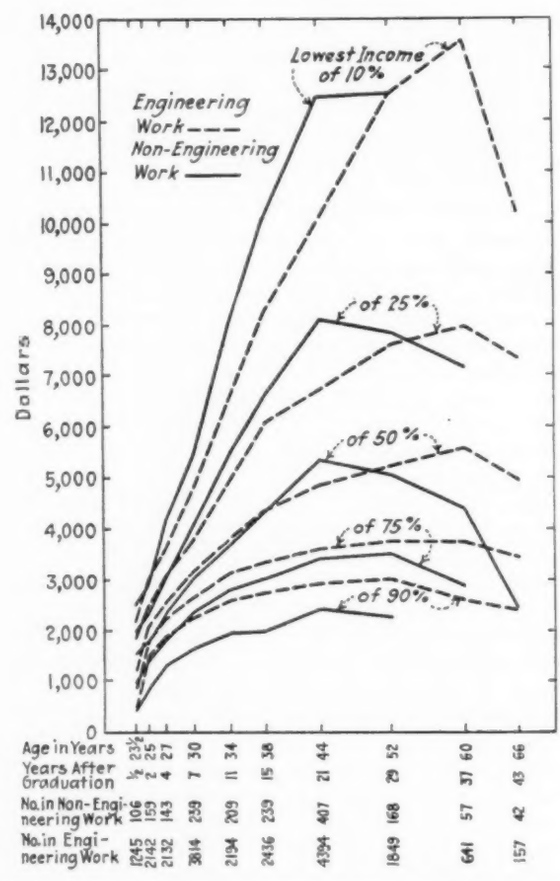
Despite the fact that in 1929 the tendency was for average annual incomes of engineers engaged in nonengineering to exceed slightly those from engineering work, the opportunities in the former field did not embrace more than 7 per cent of the total in any one age classification.

Over the period 1929–1934 the relationship changed between the jobs engineers took in engineering and nonengineering work. On the whole it appears that in 1929 nonengineering work was an alternative to engineering work, but from 1929 to 1934 many nonengineering jobs were accepted as an alternative to unemployment or work relief.

The extent to which earning opportunities from nonengineering work depreciated between 1929 and 1934 differs at the various age levels. Average earnings of two groups in nonengineering who were 28 to 40 years in 1929 declined by almost one third from 1929 to 1934. As between the groups that were over 48 years in 1929 the average income of the 1934 group is only one half the average of the 1929 group. Similarly at each of the other income levels a greater fall is found in the average income of older men in nonengineering.

Those who were able to stay in engineering fared better.

(*Continued on page 851*)



ANNUAL INCOME EARNED IN 1929 BY PROFESSIONAL ENGINEERS ENGAGED IN ENGINEERING AND NONENGINEERING WORK

(The income used in preparing this chart is primarily that reported by graduate engineers in either full- or part-time employment.)

[1] "Education of the Engineer," MECHANICAL ENGINEERING, August, 1936, pp. 505–509. Also: "Educational Qualifications in the Engineering Profession," *Monthly Labor Review*, June, 1936, pp. 1528–1542; also reprinted as Bureau of Labor Statistics Serial No. R. 400.

"Unemployment of the Engineer," MECHANICAL ENGINEERING, March, 1937, pp. 178–181. Also: "Unemployment in the Engineering Profession," prepared by A. F. Hinrichs, chief economist, and A. Fraser, Jr., Division of Wages, Hours, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, January, 1937, pp. 37–59; also reprinted as B.L.S. Serial No. R. 497.

"Employment of the Engineer," MECHANICAL ENGINEERING, May, 1937, p. 350. Also: "Employment in the Engineering Profession," 1929–1934," prepared by Andrew Fraser, Jr., Division of Wages, Hours, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, April, 1937; also reprinted as B.L.S. Serial No. R. 543.

"Security in Engineering Employment," MECHANICAL ENGINEERING, August, 1937, pp. 609–611. Also: "Security of Employment in the Engineering Profession," prepared by Andrew Fraser, Jr., Division of Wages, Hours, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, May, 1937; also reprinted as B.L.S. Serial No. R. 561.

"Earnings of Engineers," MECHANICAL ENGINEERING, October, 1937, pp. 742 and 754. Also: "Income and Earnings in the Engineering Profession, 1929–1934," prepared by Andrew Fraser, Jr., Division of Hours, Wages, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, August, 1937.

[2] "Annual Income in the Engineering Profession, 1929–1934," prepared by Andrew Fraser, Jr., Division of Hours, Wages, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, Sept., 1937.

The Library as an ENGINEERING TOOL

By GREGORY M. DEXTER

SCARSDALE, N. Y.

THE EVER-RECURRING problem that engineers particularly face is summed up in the question, "Can it be done?" Not always do engineers write the correct answer. Their failures, however, must occur at infrequent intervals if they are to justify their professional standing. Little excuse exists for those who fail to furnish the correct answer if it can be deduced, at least in part, from information available in libraries. So the library as an engineering tool is worthy of more than passing thought.

But engineers are human. Some of them find it easy to go along in the daily job without sensing or taking time to study the implications of new developments in unrelated or even in related fields of their daily activity. When suggestions are made for improved methods, many of them at sometime say, "It cannot be done." They have not had sufficient interest or leisure to find out whether conditions have changed, new developments have occurred, or the previous failure did not arise from some fault in management or application of method. They have not developed as much as they should the bump of curiosity which is characteristic of the engineer at his best. Lack of progressive ideas in many industrial organizations, resistance to new obligations in public-service corporations, use of outworn methods by some government engineers, and repetition of exploded arguments in discussions of economic questions indicate clearly that suggestions on how to use a library should be helpful to engineers and executives. Let nobody deceive himself with the belief that the proper use of a library is elementary knowledge!

This discussion must be limited to the reasonable length of an article. Comments, therefore, will be generally upon library work as it affects the engineer. Only the more valuable sources of data in the English language will be listed since most American engineers are dependent upon the knowledge available in it. An engineer who has learned to take advantage of the following help should have no difficulty in finding additional sources. Where dates are given, they refer to year of publication, year when the series of abstracts started, or beginning of the period covered by the abstracts or book.

Many engineering problems are settled easily by reference to the latest books. These must include, however, economic subjects since engineering is much more than mathematics, strength of materials, or properties of vapors. So every engineer should have near him the catalogs of such well-known publishers as John Wiley & Sons, Inc.; McGraw-Hill Book Company, Inc.; Reinhold Publishing Corporation; Ronald Press Company; and D. Van Nostrand Company. He will find that often the best book on a particular subject is not published by any of the preceding but by a house like The Macmillan Company or the University of Chicago Press. Even more startling, if he is thorough in his search for knowledge, he will find that the book he wants can be obtained only from some publisher of whom he has never heard. Every engineer, therefore, should know how to use the following:

"The United States Catalog" (books in print Jan. 1, 1928, and previous editions), The H. W. Wilson Company., New York, N. Y.

"Cumulative Book Index," 1928, The H. W. Wilson Company, New York, N. Y.

"Book Review Digest," 1905, The H. W. Wilson Company, New York, N. Y.

"Technical Book Review Index" (new), Special Libraries Association, New York, N. Y.

"The English Catalog of Books," 1801, The Publishers' Circular, Ltd., London, England.

"Books Abroad," 1927, University of Oklahoma Press, Norman, Okla.

"Reference Catalog of Current Literature," 1932, Joseph Whitaker & Sons, Ltd., London, England.

"Locating Books for Interlibrary Loan," by C. M. Winchell, 1930, The H. W. Wilson Company, New York, N. Y.

"Current National Bibliographies," by Lawrence Heyl, 1933, American Library Association, Chicago, Ill.

GOVERNMENT PUBLICATIONS

Many problems which engineers have to solve are so involved in technicalities, so unusual, or so special in application that no book available gives more than an elementary discussion. Places to which an engineer may turn then are the various departments of the Federal and State Governments as well as the numerous experiment stations.

He should have always available a complete set of the indexes of Federal publications which are obtainable from the Superintendent of Documents, Washington, D. C. They cover about everything from agriculture to labor rates, from geology to maps, from biological chemistry to cement. If the particular subject in which he is interested is not listed, a letter to the appropriate Federal department often will bring him valuable information on unpublished data or other suggestions.

Important knowledge is buried in state and municipal reports and in bulletins of experiment stations. No universal index is published for all of these but clues to them can be found usually in the following:

"Monthly Catalog of U. S. Public Documents," 1895, U. S. Government Printing Office, Washington, D. C.

"Bulletin of the Public Affairs Information Service," 1915, Public Affairs Information Service, New York, N. Y.

"Experiment Station Record," 1889, Experiment Stations Office, U. S. Department of Agriculture, Washington, D. C.

"Guide to the Official Publications of the New Deal Administration," by J. K. Wilcox, 1934, American Library Association, Chicago, Ill.

"Monthly Check List of State Publications, Library of Congress," U. S. Government Printing Office, Washington, D. C.

"Basic List of Current Municipal Documents," 1932, Special Libraries Association, New York, N. Y.

The New York Public Library has a fairly complete card index of Federal and State publications in its economics division on the second floor of its main building.

Here again, letters to the appropriate departments or ex-

periment stations in several states frequently will bring suggestive information. The State Board of Health of Wisconsin, for example, has done interesting work on disposal of waste from paper and pulp mills. The Iowa Experiment Station has made a valuable report on the manufacture of paper from cornstalks to which is appended a worth-while bibliography. The Illinois Experiment Station has done extensive work on concrete. An almost indefinite number of examples like the preceding could be given.

Canadian and British sources of information should not be overlooked. Those for Canada, except for the provinces, will be found in publications of the Public Printing and Stationery Department, Ottawa, Canada. Those for Great Britain and many other countries may be located in Serial Publications of Foreign Governments by Winifred Gregory (1932), published by The H. W. Wilson Company, New York, N. Y.

Allied to the above are the various research laboratories and technical societies of the United States which are listed in the following:

"Industrial Research Laboratories of the United States, including Consulting Research Laboratories," by C. J. West and C. Hall, Bulletin No. 91, 1933, National Research Council of the National Academy of Sciences, Washington, D. C.

"Handbook of Scientific and Technical Societies of the United States and Canada," Bulletin No. 76, 1930, National Research Council of the National Academy of Sciences, Washington, D. C.

ECONOMIC DATA

Any important report usually involves an economic discussion. This frequently means that figures as to imports and exports must be obtained, domestic production must be analyzed, effects of population changes must be considered, and labor rates are significant. If natural resources are involved, then reports by Federal and State departments must be examined. Every engineer, therefore, should know how to check his economic conclusions against those reported in government and trade publications. If he does, he will be more likely to keep his feet on the ground and not make the ridiculous mistakes which often are found in poorly or hastily prepared reports. An excellent way to locate economic data is to examine the following:

"Commercial Atlas and Marketing Guide," 1936, Rand McNally & Co., New York, N. Y.

"Market Research Sources, a Guide to Information on Domestic Marketing," 1936, U. S. Department of Commerce, Washington, D. C.

"Descriptive List of U. S. Government Periodical Mimeographed Statements," 1929, Special Libraries Association, Providence, R. I.

"Price Sources," 1931, U. S. Department of Commerce, Washington, D C.

"Handbook of Commercial and Financial Services," 1931, Special Libraries Association, Providence, R. I.

"The Market Data Book," 1931, G. D. Crain, Jr., Chicago, Ill.

"Business Directories, A Key to Their Use," 1934, Newark Public Library, Newark, N. J.

"The Economist's Handbook, A Manual of Statistical Sources," by Gerlof Verwey and D. C. Renooij, 1934. (This is valuable for countries other than the United States.) The Economist's Handbook, Amsterdam, Holland.

GENERAL INDEXES

All of the preceding sources of information still may leave the inquiring engineer with the answer to his problem no more than roughly outlined. He should turn then for the more detailed information he seeks to the many admirable trade, economic, engineering, and scientific publications which are available. His examination of them will be assisted greatly by the use of such indexes as the following:

"Industrial Arts Index," 1913, The H. W. Wilson Company, New York, N. Y.

"The Engineering Index" (since 1884), Engineering Index, Inc., New York, N. Y.

"Engineering Abstracts," 1919, Institution of Civil Engineers, London, England.

"Agricultural Index," 1916, The H. W. Wilson Company, New York, N. Y.

"Botanical Abstracts" (1918, absorbed by Biological Abstracts in 1926).

"Biological Abstracts," 1926, University of Pennsylvania, Philadelphia, Pa.

"Science Abstracts," edited and issued by the Institution of Electrical Engineers, in association with other technical societies, 1898, E.& F. N. Spon, Ltd., London, England.

"Chemical Abstracts," 1907, American Chemical Society, Easton, Pa.

Journal of the Chemical Society (for data prior to 1926), The Chemical Society, London, England.

Journal of the Society of Chemical Industry (for data prior to 1926), The Society of Chemical Industry, London, England.

"British Chemical Abstracts," 1926, Bureau of Chemical Abstracts, London, England.

"Accountants' Index," 1920, American Institute Publishing Company, Inc., New York, N. Y.

"Index Medicus," 1879, Carnegie Institution, Washington, D. C.

"Quarterly Cumulative Index Medicus," 1927, American Medical Association, Chicago, Ill.

"Index to Legal Periodicals and Law Library Journal," 1908, The H. W. Wilson Company, New York, N. Y.

"Education Index," 1928, The H. W. Wilson Company, New York, N. Y.

"Psychological Abstracts," 1927, American Psychological Association, Worcester, Mass.

Titles to some of these indexes are likely to deceive the engineer who has not had actual experience in their use. The Agricultural Index has considerable material which bears on drainage, irrigation, highways, and trucking. Chemical Abstracts will cover concrete, paper, sugar, steel, and other subjects. Botanical and Biological Abstracts, of course, get into the field of biological chemistry, which is becoming increasingly important to engineers, but answers to some problems in forestry, timber, and lumbering operations are also there. Even the Accountants Index can be used to run down articles on wage rates, labor conditions, and depreciation. The preceding examples are not exhaustive but are intended to be suggestive so that engineers who have not done so may cultivate their bump of curiosity by examining these indexes.

SPECIAL INDEXES

To the more general indexes, which have just been listed, should be added a large number of special indexes that are limited more in their scope and yet are very helpful on problems touching their fields. A partial list of the more important follows:

"A Bibliography on the Cutting of Metals," by O. W. Boston, Part 1, 1930, The American Society of Mechanical Engineers, New York, N. Y.

"A Bibliography on the Cutting of Metals," by O. W. Boston, Part 2, 1935, Edwards Brothers, Inc., Ann Arbor, Mich.

"Iron, Steel & Industrial Fuel," 1928, Iron and Steel Institute, London, England.

"Metals and Alloys," 1929, Reinhold Publishing Corporation, New York, N. Y.

"Annotated Bibliography of Economic Geology," 1929, The Economic Geology Publishing Company, Lancaster, Pa.

"Bibliography of North American Geology," by J. M. Nickles, (since 1732), U. S. Geological Survey, Washington, D. C.

"Bibliography of Bibliographies on Chemistry and Chemical Technology," by C. J. West and D. D. Berolzheimer, 1900–1924, Bulletin No. 50, 1924–1928, Bulletin No. 71 and 1928–1931, Bulletin No. 86,

National Research Council of the National Academy of Sciences, Washington, D. C.

"Catalogue of Published Bibliographies in Geology," by E. B. Mathers, 1896–1920, Bulletin No. 36, National Research Council of the National Academy of Sciences, Washington, D. C.

"Classified List of Published Bibliographies in Physics," by K. K. Darrow, 1910–1922, Bulletin No. 47, National Research Council of the National Academy of Sciences, Washington, D. C.

"Bibliography of Pulp & Paper Making," by C. J. West (1900–1928 and 1929–1935), Lockwood Trade Journal Company, New York, N. Y.

"Pulp and Paper Industry Literature" (review by Bibliography Committee of the Technical Association of the Pulp and Paper Industry in monthly issues of the *Paper Trade Journal*), Lockwood Trade Journal Company, New York, N. Y.

"Sugar Abstracts," by the International Society of Sugar Cane Technologists in issues of Facts About Sugar, 1931, Facts About Sugar, New York, N. Y.

Abstracts on silk, wool, linen, and cotton but excluding dyestuffs in the *Journal of the Textile Institute* (at least since 1922), Textile Institute, Manchester, England.

"Building Science Abstracts, 1928, Department of Scientific and Industrial Research, London, England.

"Water Pollution Research" (summary of current literature), 1928, Department of Scientific and Industrial Research, London, England.

"Nutrition Abstracts and Reviews," 1931, Imperial Bureau of Animal Nutrition, Reid Library, Rowett Institute, Aberdeen, Scotland.

"Index to Literature of Food Investigation," 1929, Department of Scientific and Industrial Research, London, England.

"Library Index, Current Periodical Literature in Field of Public Health," 1929, National Health Library, National Health Council, New York, N. Y.

"Monthly Abstract Bulletin," 1915, Kodak Research Laboratories, Rochester, N. Y.

"Photographic Abstracts," 1921, Royal Photographic Society of Great Britain, London, England.

"Colour Index," 1924, Society of Dyers and Colourists, Bradford, England.

"Bibliography of Rates for Public Utilities" (since 1815), American Gas Association, New York, N. Y.

"Bulletin of The Imperial Institute" (summaries of research in many fields, 1904), The Imperial Institute, London, England.

Numerous special bibliographies which cover limited periods will be found in the Engineering Societies' Library. These bibliographies cover diverse subjects from management to rainfall, from platinum to wood.

"Bibliography of Journals, Books, and Compilations (American and Foreign) Which List and Abstract Patents," by Elsa von Hohenhoff, 1936, Baltimore Special Libraries Association, Baltimore, Md.

"Horticultural Abstracts," 1931, Imperial Bureau of Fruit Production, East Malling, England.

"Traffic Digest" (street and highway, 1931), Institute of Traffic Engineers, New York, N. Y.

"Index to Labor Articles," 1926, Labor Research Department, Rand School of Social Science, New York, N. Y.

"London Bibliography of the Social Sciences" and supplements, 1931, London School of Economics and Political Science, London, England.

"Standard Catalog for Public Libraries—Social Sciences" and supplements, 1927, The H. W. Wilson Company, New York, N. Y.

"Educational Abstracts," 1936, Educational Abstracts, New York, N. Y.

"Child Development Abstracts and Bibliography," 1927, National Research Council of the National Academy of Sciences, Washington, D. C.

"Selected Bibliography of Engineering Subjects" Section 1, Mathematics, Mechanics, and Physics; Section 2, Aeronautical Engineering and Civil Engineering; Section 3, Chemistry, Chemical Engineering, and Industrial Engineering; Section 4, Electrical Engineering and Mechanical Engineering; and Section 5, Metallurgy, Mineralogy and Geology, and Mining Engineering; 1937, Engineers' Council for Professional Development, New York, N. Y.

"Bibliography of Management Literature," 1903 to 1935, The American Society of Mechanical Engineers, New York, N. Y.

"Woods of the World," 1928, The American Society of Mechanical Engineers, New York, N. Y.

"Marketing Research," by G. W. Kelsey, 1935, The American Society of Mechanical Engineers, New York, N. Y.

"World List of Scientific Periodicals," 1934, Oxford University Press, London, England.

"Union List of Journals, Proceedings, Annuals and Other Serials in the Chemical Libraries of the Chemistry Section, Science Technology Division of the Special Libraries Association," 1935; Merck & Co., Inc., Rahway, N. J.

"Occupational Index," 1936, National Occupational Conference, New York, N. Y.

A few sentences on how to use these indexes may be helpful. If interested in cement and concrete, look not only under those words but also under words describing applications such as "molasses," if concrete is to be used for storing it, or under generally descriptive headings such as highways, bridges, and the like. Remember that the indexer uses not the title but rather the general subject. He has not sufficient space to cross-reference an article more than once usually. So the engineer who has to find a particular article must have sufficient imagination to know where to look. If interested in water supply in Florida, he should look not only under "water supply" but also under "Florida," "geology," and such related subjects as "welds," "filtration," "pumping stations," and similar topics. Indexes are not foolproof. The engineer who uses them must have not only imagination but also resourcefulness and persistence. These are distinguishing qualities of an executive and not those of an ordinary clerk. Too many engineers regard a library search as a rather simple job and as something beneath their dignity whereas it is an increasingly important engineering tool in these days of extensive research and rapid technological progress. If engineers used libraries as much as they should, they often would discover that "It cannot be done" is a foolish statement in the light of what other engineers and scientists are doing or have done.

Information that an engineer seeks frequently will not be found in any of the usual technical and scientific publications but rather in more popular magazines and even in newspapers. He may want to know of the public reaction to some problem in a particular community or of labor conditions there. An examination of the files of a newspaper published in that community often will be illuminating. He should bear in mind that no hard and fast classification of indexes is possible and that they overlap to a considerable extent. He should, in addition, be familiar with the following:

"Reader's Guide to Periodical Literature," 1900, The H. W. Wilson Company, New York, N. Y.

"International Index to Periodicals, Devoted chiefly to the Humanities and Science" (since 1914), The H. W. Wilson Company, New York, N. Y.

"Subject Index to Periodicals," 1915, The Library Association, London, England.

"*New York Times* Index," 1913, *New York Times* Index, New York, N. Y.

"Official Index to *The Times*," 1906, *The Times*, London, England.

"Bibliography of Social Surveys to January, 1928," by A. H. Eaton and S. M. Harrison, 1930, Russell Sage Foundation, New York, N. Y.

LOCATING LIBRARIES

The engineer with the inquiring mind will discover quickly that locating articles he wishes to examine, by consulting various indexes, is only the start of his job. His next step will be to locate the magazines, proceedings, and other publications in which they appear. This will be easy for many of the more common or better known publications but otherwise will require considerable chasing about from library to library. His

search for the proper library will be made easier by consulting the following:

"Union List of Serials in Libraries of the United States and Canada," and several supplements, 1927, The H. W. Wilson Company, New York, N. Y.

"Union List of Periodicals in Special Libraries of the New York Metropolitan District," by the New York Special Libraries Association, 1931, The H. W. Wilson Company, New York, N. Y.

"Special Libraries Directory of the United States and Canada," 1935, Special Libraries Association, New York, N. Y.

"Special Libraries Directory of the New York Metropolitan District," 1931, New York Special Libraries Association, New York, N. Y.

Yet when an engineer has taken advantage of all of the preceding suggestions, he may follow numerous other leads if the problem he is studying is of sufficient importance. No index covers all magazines and trade journals. An excellent idea is, therefore, to look up those catering to the particular industry in which his problem is embraced. Some hours spent in glancing over a large number of issues of such journals usually will open up leads elsewhere which had not been encountered in the indexes. Such examination serves as a check on slovenly use of the indexes. The following will suggest the names of publications for examination:

"Periodicals Directory," edited by C. F. Ulrich, 1935, R. R. Bowker Company, New York, N. Y.

"Periodical Publications of Trade Associations," 1930, Trade Association Department, Chamber of Commerce of the United States, Washington, D. C.

"Standard Rate and Data Service," Standard Rate and Data Service, Chicago, Ill.

"Directory of Newspapers and Periodicals," 1880, N. W. Ayer & Son, Inc., Philadelphia, Pa.

"Willing's Press Guide" (English), 1874, Willing Service, London, England.

Editors of trade journals are often helpful in shedding light on economic and technical aspects of some problem.

Another lead in locating data is to consult the secretary of the proper trade association or civic organization. An engineer, therefore, should have a copy of each of the following:

"Selected Trade Associations of the United States," 1937, Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce, Washington, D. C.

"Commercial and Industrial Organizations of the United States," Domestic Commerce Series No. 5, 1931, Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce, Washington, D. C.

"Organizations in the Field of Public Administration," 1936, Public Administration Clearing House, Chicago, Ill.

Salesmen for manufacturers of electrical, chemical, and mechanical equipment are probably the best source of help to an engineer if he wants to get the latest commercial information as to possibilities in better operating methods, lower unit costs, and necessary investment. Every engineer is well-advised who is friendly with salesmen so that he keeps fresh over a period of years the contacts he has made from time to time. For those engineers who do not know to what manufacturer to turn, information may be obtained from the following:

"Thomas' Register of American Manufacturers," Thomas Publishing Company, New York, N. Y.

"MacRae's Blue Book, Consolidated with Hendrick's Commercial Register," MacRae's Blue Book Co., Chicago, Ill.

"Mechanical Catalog," The American Society of Mechanical Engineers, New York, N. Y.

"Chemical Engineering Catalog," Reinhold Publishing Corporation, New York, N. Y.

"Sweet's Catalog File," Sweet's Catalog Service, New York, N. Y.

"Kelly's Directory of Merchants, Manufacturers and Shippers of the World," Kelly's Directories, Ltd., London, England.

Numerous theses are published or abstracted each year at various universities which are at times helpful. These may be located through the following:

"A List of American Doctoral Dissertations," Library of Congress, 1912, U. S. Government Printing Office, Washington, D. C.

"Doctoral Dissertations Accepted by American Universities," 1933, The H. W. Wilson Company, New York, N. Y.

SPECIAL LIBRARY FACILITIES

Most libraries have special bibliographic facilities of their own which should not be overlooked. The Engineering Societies Library has indexed, for example, a large number of bibliographies such as are now published in most important new books or which it has made up in connection with some library search. Many industries have endowed schools of research or instruction at universities, which are devoted to the interests of the supporting industry. A letter to the librarian at the particular university involved often will bring help. Every library usually indexes each book or pamphlet under not only its title and author but also under general headings, such as irrigation, housing, paper supplies, paper machines, and the like, and under general descriptions of localities as California, Philippine Islands, and other geographical divisions. Resourcefulness in ferreting out and in using these special bibliographic or index facilities usually pays big dividends in data obtained. Dogged persistence in combing every imaginable index heading related to the subject of investigation frequently will turn up a book or article whose title is not at all descriptive of its contents. Satisfactory information as to water requirements of various kinds of paper mills, for example, is difficult to find under "Paper-Mills—Water Supply," but definite data will be found under "Paper Mills—Waste Disposal." Probably the best description in the English language of one source of pulp for paper is in a book of three volumes on the Silviculture of Indian Trees, yet many engineers would pass over the title as uninteresting. Even when a search is completed apparently, an engineer will find it worth-while to talk with editors of trade papers, librarians, and brother engineers who may be well informed since suggestions of leads for further investigation undoubtedly will be obtained. The thorough engineer, whether examining a public utility or making a library search, turns up every stone in his path to see what is underneath. The older he grows, the more convinced he becomes that the last stone turned up is the one he could have afforded least to miss.

New York City has excellent library facilities if an engineer knows how to use them. No engineer whose work ties into agricultural chemistry should overlook the libraries of the New York and Brooklyn Botanical Gardens or similar libraries in other cities. This same comment applies to the libraries of the American Museum of Natural History and the American Geographical Society for the engineer whose interest is in natural resources where geology, maps, and economic geography are of great help. The library of Columbia University will be found astonishingly rich at times in books not elsewhere available. An unsuccessful search of the Engineering Societies Library and the New York Public Library should serve only to whet curiosity as to what smaller and less well-known libraries may have. One library can borrow books for examination from another. And when all public libraries fail, an engineer should try to get an introduction that will open the doors of some private library. He should remember, even if he cannot get the help he wants in his own city or in New York, that the Congressional Library in Washington, the John Crerar

Library in Chicago, or the libraries of such universities as Yale and Cornell are still available. A few dollars spent in railroad fares often will save many more dollars for unnecessary work and even an unwise capital investment in new facilities.

Methods of indexing are not standardized so that each library is likely to have its idiosyncracies. The American Geographical Society in its library, for example, indexes all maps in every book and pamphlet that it files. When seeking specialized knowledge as to rainfall, geology, and what not, such an index is valuable to save expense in making up maps that may be already available in satisfactory form. What is true of libraries in New York is probably true also in less degree of libraries in other cities.

Services of a librarian often are used in making searches for engineers. No disparagement of the value of such services is intended, yet this discussion will have failed of its purpose if engineers do not recognize how much better results could be obtained by an engineer instead of a librarian. The former appreciates all ramifications of the problem he is investigating. He needs, of course, the facility a librarian has in knowing how to use a library. He needs persistence and imagination. Yet an engineer who knew his subject and had those qualities plus some knowledge of a library undoubtedly could do a better job of searching than a librarian. Merely glancing over an article would tell him whether it was worth abstracting or only listing in his bibliography. A plea, therefore, to use properly qualified engineers on library investigations should have the endorsement of engineering and manufacturing executives. Then we would see more often, as in the New York Public Library recently, several engineers and chemists spending weeks for one well-known chemical company in a search of technical literature.

MISCELLANEOUS HELPS

Every engineer who takes a broad view of his profession, is active in community organizations, and has hobbies outside of his daily work will at times want help in library searches other than those suggested above. He should turn to such outlines of bibliography as the following:

"Guide to Reference Books," by Isadore Mudge, 1936, American Library Association, Chicago, Ill.

"Reference Books," by John Minto, 1929 and 1931, The Library Association, London, England.

"Bibliography, Practical, Enumerative, and Historical," by H. B. Van Hoesen and F. K. Walter, 1928, Charles Scribner's Sons, New York, N. Y.

"The Bookman's Manual," by Bessie Graham, 1935, R. R. Bowker Company, New York, N. Y.

"Bulletin of Bibliography," 1897, F. W. Faxon Company, Boston, Mass.

Encyclopedias might be put in the same category as the preceding. Their possible help, even on rather technical problems, should not be overlooked by the engineer. The Encyclopedia Britannica is so well known that it hardly needs to be mentioned but others less well known should not be omitted, such as the encyclopedias of Social Sciences and American Horticulture. Engineering handbooks fall in this same class. Many articles in these publications are accompanied by lists of books that may be consulted for further information.

SIGNIFICANCE OF SEARCHES

No engineer, however, should get the idea that a library search is a method of avoiding original thinking. It is only a method of avoiding unnecessary expense in repeating mistakes that other men have made. It is a way of trying to start with new designs, inventions, or developments where other engineers and inventors have stopped. It will bring worth-while results only when every statement is weighed as to its value, questioned as to its soundness, and analyzed as to its possibilities. Every engineer should always keep in mind the difficulty of properly evaluating all factors of a problem. He should remember, for example, various absurd predictions, in the light of our present knowledge, which were made about automobiles, according to an article on The Horseless Carriage, by Malcolm R. Eiselen, in the *Yale Review* for Autumn, 1936:

> No better will be made; time cannot improve it (1899).
>
> Small probability that the motor vehicle will displace the bicycle in popular favor.

Yet one visionary foresaw that motorbus lines ultimately would connect such cities as Cleveland and Chicago but apparently nobody foresaw our problems of traffic accidents and parking. So every engineer who faces a new problem should do so with a humble mind in the hope that he may be more successful in predicting the possibilities of any new development on which he may be working than those writers who have been quoted by the *Yale Review*. A library search will not answer all aspects of a problem nor will it take the place of original thinking in sizing up new inventions or designs, but it will set an engineer to thinking of the possibilities and in so doing lead him to sounder conclusions. His answer to the question, "Can it be done?" will be given with more assurance that he is right.

CARD INDEX AND PERIODICAL FILES IN THE ENGINEERING SOCIETIES LIBRARY, NEW YORK, N. Y.

Working Methods for
PLANNING AND CONTROLLING PROFITS

By RONALD H. ROBNETT

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE OLD saying that "nothing is so certain as change" was never more true than today. Conditions of rapid change bring unusual opportunities for the progressive concern but they complicate the problems of management. The book "Managing for Profit"[1] was written as an aid to management in planning and controlling profits, under today's complex conditions. The authors vigorously defend the right of a company to earn profits. Theirs is an enlightened concept based upon the need of humans to have an incentive to progress. A company which consistently makes no profit cannot spend money for research and development, cannot improve its product, and cannot be just to its employees. The authors have no sympathy with "the motive of profit for the sake of profit and regardless of the human angles of our modern civilization," but they do insist that business must make profits to be healthy and that it must be healthy if all classes of humans are to advance.

At the risk of oversimplification, the theme of the book might be reduced to the following basic point. The way to assure profits is first to pre-plan your sales income. Deduct from this amount a fair minimum profit. The balance is the sum available for "allowed costs." If the profit expectation is to be attained, management must find ways and means to operate the business under the "allowed cost." An analogy would be that of the individual on salary who found himself unable to save any money over a period of years. He finally decided to deduct ten per cent from his monthly salary as the first expenditure of the month and put it into a savings account. The remaining ninety per cent was his "allowed cost" for the month. In this way he rigidly controlled his expenses and gradually accumulated a sum for travel, education, or other types of "progress."

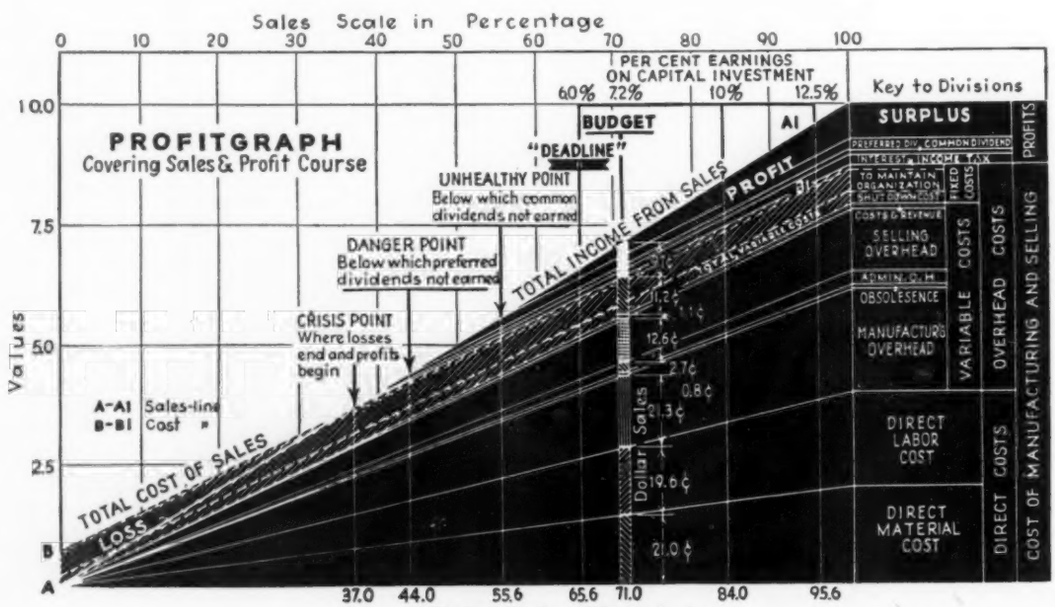
Of course, the problem is not as simple as this. Many forces may operate to modify estimates of sales income or to shift the emphasis between lines of product which may carry different gross margin percentages. Adverse changes in volume have a disconcerting effect upon unit costs because of the well-known tendency of some costs to be fixed in nature while others vary in proportion to volume. The authors recognize these facts but are not dismayed by them. It is their contention that management imbued with the profit philosophy and fortified by the proper planning and interpretive tools can do much to assure consistent and satisfactory profits.

The management tool upon which they place the greatest reliance is the Knoeppel Profitgraph (see Fig. 1), developed and perfected over the past twenty years by the senior author of the book.[2] This is a graphical presentation of sales and costs from zero to 100 per cent capacity. Costs are broken down into their various classes after having been analyzed into fixed and variable components. The "break-even" point is established, to

[1] "Managing for Profit," by C. E. Knoeppel, with the collaboration of Edgar G. Seybold, M.E. McGraw-Hill Book Company, Inc., New York, 1937.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[2] C. E. Knoeppel died on November 29, 1936, as the book was on the press.



A Profitgraph of a well-known business.

FIG. 1

the left of which is charted the losses while to the right the profit "V" appears. Charges against operating profits, such as interest, income tax, and preferred and common dividends, all have their places on the chart. The residual earnings (at higher volumes in this example) appear as additions to surplus.

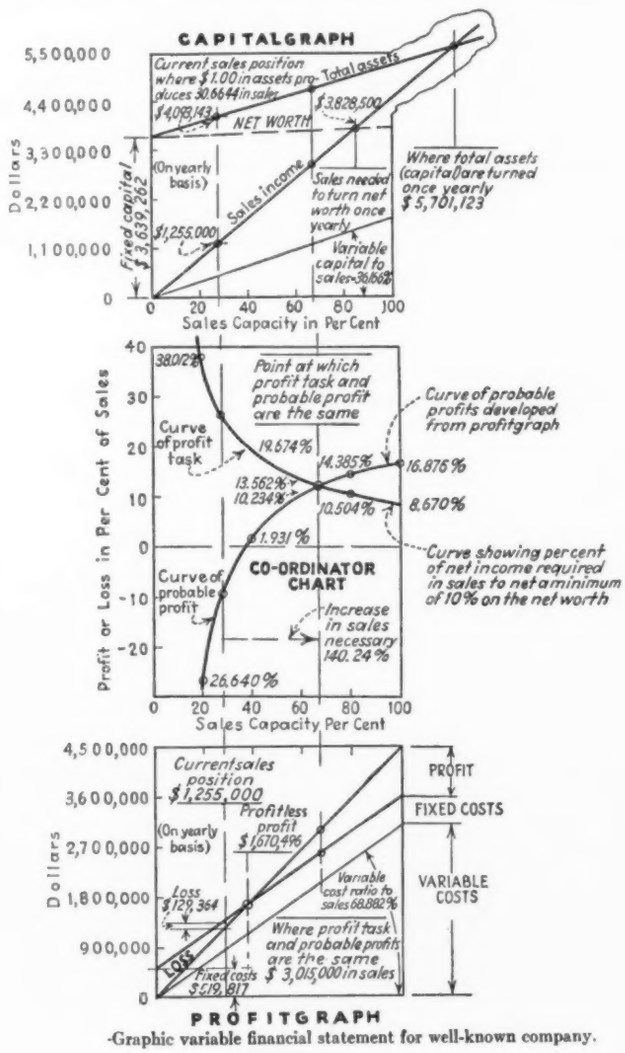
A second tool suggested is the Capitalgraph. On this chart fixed and variable assets and net worth are plotted against sales income in order to reflect sales turnover and to measure the adequacy of return in terms of assets and net worth. Fig. 2 illustrates the Capitalgraph and Profitgraph, together with a "Coordinator chart" which serves the function of "relating the curve of profit task and that of the probable profit, resulting in a new crossover point of real value to management." A detailed explanation of the technique of preparing the charts is given in part 2 of the book.

The problems of organizing for profit planning and control are given thorough treatment. The function of coordination is assigned to the controller who is given responsibility for profit planning and control. He should be responsible directly to the chief executive and should rely on the engineers for aid in this and other important tasks.

Other chapters discuss the various aspects of control with emphasis on such timely topics as variable budgets, sales planning and analysis, relation of cost accounting to profits, controlling production, wage and progress incentives, and profits from the elimination of waste.

The book does a real service in bringing together a number of vital chapters on the problems of planning and control. Every business man should be acquainted with the control techniques described and explained. The book's chief weakness is the enthusiasm of the authors for particular methods. Graphical methods are useful, particularly in presenting concepts to executives who are "picture-minded." In the final analysis, they are tools, withal valuable ones, and cannot be expected to earn profits in themselves.

It takes hard thinking, creative and careful planning, flexibility to meet change, and coordinated control to earn profits. The controller must use the greatest of judgment in presenting his reports, and must be fortified with a variety of modern tools if he is to be of greatest service to the production, finance, and sales executives, and to the stockholders of the business. Every controller should have a knowledge of the principles underlying the Knoeppel graphical methods. Properly used, they can materially increase his effectiveness.



-Graphic variable financial statement for well-known company.

FIG. 2

Annual Incomes of Engineers

(*Continued from page 844*)

Furthermore the changes which occurred in the earnings from engineering work, as reported by all engineers and by graduates only, were consistently uniform.

Relative changes as between nonengineering earnings and those for engineering work of engineers, with advancing age and experience, are also found to be the same for men with comparable periods of experience.

Among those newcomers who were trying to force their way into the profession the greatest fall in income occurred. Thus average earnings in engineering in 1934, 2 years after graduation, were 37 per cent less than in 1929. Earnings of those who had been out of college 10 years were 31 per cent lower in 1934 than in 1929. At higher ages all groups averaged a decrease of 26 per cent.

In 1934 almost one tenth of the engineers were unemployed or on work relief at the end of the year. The low level of earnings of this group during 1934 contributed to lowering the average earnings of all engineers. Thus of those engineers who were unemployed at the end of 1934 the average earnings for the preceding 12 months of those who were less than 28 years of age ranged from $700 to $950. Engineers of 40 to 50 years averaged $1350. Only about 10 per cent of the unemployed, even though they were of those ages at which engineering earnings reached a peak, had made as much as $2000 in the preceding 12 months. Ten per cent made less than $300 a year.

The earned annual-income data used in the preceding analysis were those reported for personal services of all classes of engineers, irrespective of whether or not they were engaged primarily in engineering or nonengineering work. They related, in other words, to the incomes of engineers, not to the incomes of men engaged in engineering. Consideration is here given to the annual incomes, classified by age, as related to the professional engineers' employment status.

While income was reported for the year, the type of employment was reported only as of Dec. 31, 1929, 1932, and 1934. Consequently it has been necessary to assume that the kind of engineering or nonengineering employment engaged in at the end of the year was the source of the income for that year. This assumption makes possible valid general comparisons of the earnings of engineers in these two types of employment.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context, and credit to original sources is given.

Day by Day

ODDS AND ends of day-by-day newspaper and other comment on events that make the engineer prick up his ears and note with satisfaction that members of his profession are being honored or that some of their activities are arresting public attention are summarized in what follows.

PERSONAL

Appointments, honors, and awards provide the greatest number of items in this month's day-by-day record.

On his seventieth birthday Simon Lake, submarine designer, is reported to have told newspaper reporters that underwater cargo ships may be used in the next war. He is said to have announced perfected plans for cargo-carrying submarines, now capable of displacements as great as 13,000 tons.

To succeed Maj. Gen. Edward M. Markham on October 17, President Roosevelt has approved the appointment of Col. Julian L. Schley, commanding the Engineer School at Fort Belvoir, Va., as Chief of Engineers, with the rank of Major General.

At Lehigh's Founders' Day, E. G. Bailey, member, A.S.M.E., was honored by the university with the degree of doctor of engineering. Yale's new professor of civil engineering, Hardy Cross, was given a similar degree.

By his Alma Mater, in connection with the 150th anniversary of the establishment at that institution of a chapter of the honor society, Phi Beta Kappa, Otis E. Hovey, member, A.S.M.E., was made an honorary member of the chapter. Not being an arts student, as an undergraduate Mr. Hovey was not eligible at that time for the distinction of membership, although his college record warranted his receiving the honor.

On October 15, announcement was made that Mr. Hovey had been chosen director of the Engineering Foundation, to fill the place left vacant by the death of Alfred D. Flinn.

The Engineers' Club of Birmingham has announced that T. M. Francis, member, A.S.M.E., has been appointed to the Engineering Council of the Birmingham Chamber of Commerce.

H. Birchard Taylor, of Philadelphia, fellow, A.S.M.E., has accepted appointment as executive director of the University of Pennsylvania's $12,500,000 fund-raising campaign which opened October 18 in anticipation of the university's 200th anniversary celebration in 1940.

The Samuel Wylie Miller Medal, an annual award of the American Welding Society, presented for meritorious contributions to the science and art of welding, has been awarded to H. Sidney Smith, member, A.S.M.E. For many years and until the time of Mr. Miller's death, Mr. Smith was closely associated with Mr. Miller, for whom the medal is named, in technical, business, and engineering-society activities.

Before the Seventh Annual Forum on Current Problems, conducted by the New York *Herald Tribune* during the week of October 6, W. L. Batt, president, SKF Industries, and past-president, A.S.M.E., spoke on opportunities for young men in business and qualities of character and training favorable to success. Mr. Batt repeated the opinion, frequently discounted by the cynical, that "push" is a far more useful asset to a young man in getting a job than "pull."

Study, he said, certainly does pay for one who expects to go into business, because business success is most likely to come to the man who will work, who will tackle a job and get it done, and who will use his head. Just as the man who showed such qualities in school was most likely to succeed there, so also he will be most likely to succeed in business.

The man who will develop his talents in some particular direction, he asserted, will find it easier to get a job and keep it.

E.C.P.D.

As noted in the A.S.M.E. News, page 883, the Engineers' Council for Professional Development convened in New York on Sept. 30 and Oct. 1, 1937, for its fifth annual meeting. Interest centered around accomplishments to date and rate of progress being made on the program of student guidance and post-collegiate education of young engineers, and on the report on the program of accrediting engineering-school curricula which has now covered 127 schools throughout the entire nation.

ERIE

Enthusiastic comments heard by members of The American Society of Mechanical Engineers indicate that the Society's new four-meeting-a-year plan will have supporters. The first National Fall Meeting, held at Erie, Pa., Oct. 4 to 6, 1937, which inaugurated this plan, is fully reported in the A.S.M.E. News on pages 873 to 876 of this issue.

UNIONS

At its third annual convention held in New York in October, the National Society of Professional Engineers proposed in a resolution the amendment of the National Labor Relations Act to exempt professional men "from any requirement to be represented by any professional organization for collective bargaining."

While the right of engineers to join unions and to strike if necessary was defended on the grounds that it would be to their disadvantage to be jockeyed into a position where they would be known as an antilabor or antiunion group, it was also asked if anyone had ever heard of a doctors' or a lawyers' strike, and why could not engineers govern themselves along these lines. One speaker pointed out that because of the importance of their positions engineers could not strike, as in doing so they would violate their oath to "safeguard the health of the community." Another said that affiliation with any labor union would change the status of the engineer from that of the professional to that of the trades-union group.

Another resolution passed by the convention called for the establishment of a Cabinet post to be known as the Secretariat

of Public Works. Arthur V. Sheridan was reelected president for 1938, and Pittsburgh, Pa., was chosen as the place at which the 1938 convention will be held.

REORGANIZATION

According to the September News letter of the American Engineering Council, consideration of proposals for the reorganization of the Federal Government is certain to be an issue of vital importance to the next Congress. None of the pending legislation provides for the consolidation of public-works engineering and construction activities or the creation of a Public Works Department. The President's Committee suggested a Public Works Deparment and the President included the suggestion in his message to Congress on reorganization, but thus far, Congress has ignored it and the investigation made by the Brookings Institution opposes it.

COAL

Newspaper accounts of certain features of the release of the Pennsylvania State Anthracite Coal Commission's report played up the so-called "bootleg" coal industry. The report, issued by W. Jett Lauck and prepared by James W. Angell and P. Bernard Nortman, estimated that in 1936–1937 the bootleg-coal industry produced and sold 2,400,000 tons of anthracite, about 5 per cent of that legally mined in the same period. Consumers are said to have paid $16,000,000 for bootleg coal last year. This "outlaw" industry is credited with having been the sole means of sustenance for 45,000 persons in Pennsylvania. According to estimates, about 13,000 are now actively engaged in it, of which 8300 are in coal holes and breakers, 2000 in picking over culm banks and refuse piles, and 2700 in trucking.

In a later dispatch Mr. Lauck is asserted to have recommended purchase of excess anthracite reserves in Pennsylvania by the state. Excess reserves are defined as all coal lands owned or controlled by producing companies beyond the needs of the next 25 years.

Of literary interest is the report from Lanarkshire, Scotland, that the 175-year old Douglas Castle will be demolished to permit the mining of coal veins beneath it. The owner of the castle that was made famous by Sir Walter Scott as "Castle Dangerous" is the Earl of Home, who is said to have reported that the opening of the new seams will avoid an increase in local unemployment inasmuch as older seams are being worked out.

SHIPS

Chairman Kennedy announced early in October that the Newport News Shipbuilding and Drydock Company's bid of $15,750,000 for the construction of a new merchantman to replace the *Leviathan* had been accepted by the Maritime Commission. Bids for scrapping the *Leviathan* in the United States or Europe are being asked, thus dooming to extinction the famous vessel that transported so many troops during the War.

TANKS

At Indiantown Gap, Pa., a new army tank capable of making a speed of 50 mph over rough ground was put to test. The tank operates with a four-man crew, but specifications have not been made public. It is said that in addition to the driver the tank carries one machine gunner at the driver's right and two in a swinging turret. The driver receives orders by radio, and one tank of each company of five is said to be equipped with a sending set.

STOKERS

In a report growing out of a seven-year investigation by the Interstate Commerce Commission, as the result of a complaint filed in November, 1930, by the Brotherhood of Locomotive Engineers and the Brotherhood of Firemen and Enginemen, Special Examiner H. C. King is said to have recommended that railroads be required to equip approximately 3500 locomotives now in service with automatic stokers "in the interest of safety." The aggregate cost of carrying out the recommendation is estimated to be not more than $11,000,000.

AIRWAYS

At a press conference on Sept. 22, Secretary Roper, of the Department of Commerce, made public a memorandum with regard to the allocation of funds for the modernization and improvement of the Federal Airways System. The memorandum states that for the establishment of air-navigation facilities for the fiscal year 1938 the Congress appropriated $3,000,000 with the proviso that the Secretary of Commerce could incur additional obligations, not exceeding $2,000,000, prior to June 30, 1938, and could incur further contract obligations not exceeding $2,000,000 prior to June 30, 1939. This in effect provides for a $7,000,000 airways construction and improvement program, although only $3,000,000 of the total is available for expenditure in the present fiscal year. The first $5,000,000 available is being applied to the modernization and improvement of the existing Federal Airways System.

LOCOMOTIVES

Two novel locomotives got into the news during the last month. One is the new Baltimore and Ohio 16-cylinder constant-torque steam locomotive capable of developing 5000 hp. The new locomotive has a four-wheel front truck, four pairs of drivers, a four-wheel trailer truck, and a tank mounted on two six-wheel trucks carrying 23 tons of coal and 22,000 gal of water. Each of the four driving axles will be driven by a Besler steam motor, and each motor has four cylinders geared directly to the axle. No counterbalancing and no main rods, side rods, or crankpins will be required. The total weight of the locomotive will be about 400,000 lb with 260,000 lb on the drivers. The tractive power will be 72,500 lb, giving a factor of adhesion of 3.6. The boiler will be of the Emerson water-tube firebox type with 775 sq ft of heating surface in the firebox and a total heating surface of 5800 sq ft. Superheating surface will be 1530 sq ft. The Besler steam motors operate on a guaranteed rate of 14 lb per hphr. Working pressure of the motors is 350 lb per sq in.

According to the *New York Times* the possibility of building in this country a condensing steam-turbine locomotive with mechanical drive was mentioned by L. P. Michael, chief engineer, Chicago and Northwestern Railway, at a meeting in Chicago of the Railway Fuel and Traveling Engineers Association. It is proposed, Mr. Michael is reported to have said, to generate steam at a pressure of 1250 lb per sq in.

Members of the A.S.M.E. in attendance at the National Fall Meeting of the Society were privileged to see in process of erection at the Erie works of the General Electric Company the two-unit steam-turbine electric locomotive being constructed for the Union Pacific, boilers for which are of the Steamotive type described at the 1936 Annual Meeting of the Society in a paper in MECHANICAL ENGINEERING for December, 1936.

EDUCATION

Paul J. Kern, member of the Municipal Civil Service Commission, New York, announced in September that first steps were being taken to ask the Commission to approve a program of employing 10 recent graduates of Columbia, College of the City of New York, New York University, and Cornell as cadet

engineers for the Board of Transportation. The proposed apprentice period is to be for 16 months and the aim is to make civil service a career service that will attract young men of proved scholastic ability and superior training. At the end of the training period the young men will be expected to prove their right to continue by participating in open competitive examinations on the same terms as other applicants. Should the plan prove to be worth while, it was said, it will be extended to other departments having engineering functions.

DEDICATION

On October 15 and 16 the University of Delaware dedicated, with an appropriate program of addresses and conferences on chemistry and chemical engineering, including the conferring of honorary degrees, a new chemical laboratory.

FILENE

At Paris, France, on Sept. 26, 1937, Edward A. Filene, Boston merchant and active student of social and economic problems, died of pneumonia at the age of 77. Best known to engineers for his interest in problems of distribution and management, Mr. Filene was an active proponent of the high-wage theory for the maintenance of mass purchasing power. He was international in his social and economic interests, spending much time abroad in the study of conditions and opinion in other countries. In the later years of his life he gave much attention to cooperative credit organizations. Greatest of his philanthropies was the Twentieth Century Fund, estimated at about $1,000,000, which he established in 1919. Originally aimed at providing donations for surveys in all fields of social work, the Fund's activities in recent years leaned largely toward economic studies. Latest of the Fund's reports, that on "Big Business" was reviewed in our October issue. Among Mr. Filene's books was one entitled, "Successful Living in this Machine Age."

On October 10 announcement was made of the formation of the Institute for Propaganda Analysis, financed by the Good Will Fund set up by Mr. Filene. The Institute will operate as a nonprofit corporation with the eventual aim of supporting itself through subscriptions. It will attempt to assist the average person to form sensible appraisals of press, radio, and newsreel disseminations by issuing monthly newsletters of analysis on current problems. Hadley Cantril, of Princeton University, will act as president of the Institute and Clyde R. Miller, of Teachers College, Columbia University, as secretary.

MASARYK

At Prague, Czechoslovakia, on Sept. 14, 1937, Thomas G. Masaryk, founder and former president of the Czechoslovak Republic, died at the age of 87. Honored and beloved by his people for his extraordinary services and the simplicity of his character, this modern statesman, the son of a coachman, secured an education against great handicaps and became a philosopher. He entered the Imperial Parliament as a Liberal in 1891, and in 1900 established the Realist party. In 1914, at the outbreak of the War, he slipped out of his own country and worked abroad, with a death penalty hanging over him, in the cause of Czechoslovakian independence and, in 1916, issued a revolutionary manifesto and set up the Czechoslovakian National Council, which he headed. In 1918 he organized an army of Russian Czechs and prisoners, and, unable to make his way westward, set off toward the east via Siberia. Leaving his corps in Siberia and coming to the United States, he signed, on October 18, 1918, at Philadelphia, Pa., the Declaration of Czechoslovakian Independence. With recognition of that independence by the United States and other allied powers, and following the revolution that began at Prague, Oct. 28, 1918, Masaryk was proclaimed president on Nov. 5, 1918. Returning to his native country he assumed office on Dec. 21, 1918. Having welded together the national interests he began the work of rebuilding a poverty-stricken nation and its industries and school system. Success in the modernization of industry was partly the result of the adoption of Western methods, and in 1924 the Masaryk Academy of Work conducted the First International Management Congress, to which American engineers were invited. Many members of The American Society of Mechanical Engineers attended the Congress and several were highly honored by the Czech government. Friendly relations between the A.S.M.E. and the Masaryk Academy of Work have persisted, with the result that the name of Masaryk has more than a political significance to American engineers.

Aeronautic Radio

BUREAU OF AIR COMMERCE

ANNOUNCEMENT of the fact that the Department of Commerce contemplates expenditure of considerable amounts of money in improving and extending aids to aerial navigation, noted in a recent issue, lends interest to Aeronautics Bulletin No. 27, Bureau of Air Commerce, U. S. Department of Commerce, dated July 1, 1937. A section of this Bulletin is devoted to such new developments as simultaneous transmission, the radio compass, blind-landing systems, radio teletypewriter and radio facsimile transmission, and the cone-of-silence marker.

By means of simultaneous transmission of radio range signals and voice, supplanting alternate transmission, the pilot may continue to receive the former and yet be aware that other messages, such as weather conditions, are being broadcast for his benefit. One set of filters in the receiving set will admit the radio range signals and reject the voice; the other will admit the voice and reject the range signals. The pilot selects his method of reception by means of a switch. With the switch in one position he receives both voice and radio range signals; in another he gets voice only, and in the third, range signals only. Ordinarily, he will have his headphones connected so that both will be heard. Most of the time only the directional signals will be on the air. At the same time he will be sure of knowing whenever voice broadcasts go on the air. He is then able to listen to whichever is of greatest value to him.

Navigating with a radio compass the pilot turns on the radio-compass receiver and moves the station selection to the frequency of the station he desires to pick up. He tunes in on this station until the maximum volume is received and from that time on he merely watches a needle on his instrument board which is pointed vertically at zero. If the plane veers off to either side of the course, the needle will move accordingly and warn the pilot.

Blind landing is said to be still in the experimental and testing stage, and is not in regular use in any commercial operations, but the Bureau is continuing its investigations of various proposed methods.

The Bureau is also developing the application of radio teletypewriter and radio facsimile transmission to the Federal Airways System. Radio facsimile transmission as tested by the Bureau is based on the scanning principle. The message to be sent is typed or written on a strip of paper tape. The tape with the message is led into the transmitting set where the scanning beam passes rapidly over the letters and causes radio

impulses to be broadcast. At the receiving end the impulses are translated into extremely black lines which make up the separate letters of the words. The scanning beam passes over each letter numerous times and thus the character appearing on the tape in the receiving machine is made up of a similar number of tiny black lines. The system sent 76 words a minute during tests. Its peculiar advantage over other systems of radio transmission in which written or typed messages are reproduced automatically is its ability to go through station or heavy background noise. Static will not produce errors.

The cone of silence, a zone in which no signals are heard directly above the transmitting towers of a radio range transmitting antenna, is the indication to an airman, following a range course and endeavoring to orient himself, that he is directly over the sending station.

Some pilots have confused the momentary fading of the range signals over mountainous country with the cone of silence, and also at times they have had difficulty locating this zone when flying in turbulent weather and at low altitudes. The Bureau of Air Commerce attacked this problem by building an ultra high-frequency transmitter which projects a vertical beam in the cone-of-silence area. To receive this special beam or signal, the airplane need add only a small, light, compact receiver which is constantly tuned to one frequency and will receive the special signal from any radio station so equipped. The receiver picks up the signal and in turn lights a small light on the instrument board as the plane passes through the cone of silence. If the pilot desires he may use his headphones in conjunction with the light to advise him when he has passed over the station.

The ultrahigh-frequency marker has been thoroughly flight tested and is considered satisfactory for service installation at all radio range stations.

High-Speed Tensile Tests

JOURNAL OF THE INSTITUTE OF METALS

INVESTIGATION of the effect of the time factor in tensile tests of materials are reported by Dr. W. Ginns in a paper entitled, "The Mechanical Properties of Some Metals and Alloys Broken at Ultra High Speeds," to be found in volume 61 (1937) of the *Journal of the Institute of Metals*. The paper was presented to the Institute of Metals at its meeting in Sheffield, England, Sept. 6 to 10, 1937.

In the tests reported the mechanical properties of steels, copper, brasses, and aluminum alloys, broken in tension at high speed, were investigated. The average time taken to reach the yield point was 0.001 sec and to fracture, 0.005 sec. Obviously, mechanical recording apparatus for strain and stress could not be used because of inertia effects, and electrical methods, using the cathode-ray oscillograph, were developed.

The salient feature of the new type of impact machine used in tests was the method of applying the load. A strong plate spring is held in rollers at either end and deflected vertically at the center to a known degree. One end of the specimen is held in a self-centering chuck fixed to the center of the spring and the other end is held in a similar chuck attached rigidly from above. The spring can be released suddenly to fracture the specimen, which is thus subjected to direct tension.

A pressure-resistance method was used for measurement of stress and a photocell method for strain, the two being combined to give a diagram on the cathode-ray oscillograph.

Results of the test showed that, compared with the ordinary commercial tensile-test values, (*a*) the yield point is increased considerably, more than 100 per cent being recorded for some materials; (*b*) the maximum stress is increased by a much smaller amount; (*c*) the percentage elongation and the percentage reduction of area show comparatively small changes; and (*d*) the types of fractures are almost identical with those obtained for the slow test.

Once-Through Boilers

THE STEAM ENGINEER

THE TREND of development in steam generation in Russia is outlined in *The Steam Engineer* for September, 1937, in some notes translated from *Sovetskoe Kotloturbo-stroenie*. It is reported that the Russian boiler industry, under Prof. L. K. Ramzin, has decided on once-through steam generators for its future building program.

The 1937 program provides for 26 once-through boiler units, generating in all 1,300,000 kw. Of this number, 19 units, generating 1,000,000 kw, will work on high pressure, namely 2000 lb per sq in.

At the present time there are in the U.S.S.R. two Loeffler boilers with a capacity of 330,000 lb per hour each working at a pressure of 1850 lb per sq in., and also two once-through boilers; namely, the experimental Ramzin boiler built in 1931 and the commercial edition of that boiler started up in 1933 and rated at 440,000 lb per hour at 2000 lb per sq in. pressure.

Although both the Velox and the La Mont boilers are being investigated by the Central Boiler and Turbine Institute, the present development is planned around the designs of Professor Ramzin, whose boiler has been exhaustively tested during the first three years of its life.

From the standpoint of the Russian boiler industry the cardinal advantage of the once-through design lies in the absence of the heavy and very costly drums. The production of these drums, especially if intended for high pressure, necessitates expensive and complicated steel-works equipment and thus places the Russian engineer in a position of some difficulty. An interesting side light on the amount of metal required for a boiler drum is given by the figures published by I. M. Shamraevsky in *Sovetskoe Kotloturbo-stroenie* in 1935, according to which the weight of the finished drum represents from 17 to 25 per cent of the weight of the original billet, the rest of the metal being wasted during the manufacture. The abolition of drums therefore results in a very considerable saving in metal, a point of great importance at the present time.

The forced circulation employed in the once-through design allows further economy in metal by removing the many lightly loaded tubes which are a feature of the natural circulating system. Professor Ramzin computes that, with a working pressure of 2000 lb per sq in., 75 to 80 per cent of the metal used in a drum-type boiler represents dead weight, only the remaining 20 to 25 per cent being utilized as the heating surface proper. For the once-through boiler of his design he gives the figure of the useful weight as 50 per cent for the O.S.P.N. 4/140 boiler (experimental) and 48 per cent for the S.P.P. 200/140 boiler, both working at 2000 lb per sq in.

Nor is this all, for the positive character of the forced circulation leads to a great increase in the rate of evaporation per square foot of the heating surface. The comparative figures for the drum-type and once-through designs are 37 and 140 lb per sq ft per hr, respectively. This difference is due in part to the great freedom in the arrangement of the heating surface given by the use of forced circulation, which allows the designer to

shape his boiler not to suit the circulating system, but to reach the maximum efficiency of firing and of the heat transfer. A further saving in metal is therefore possible.

High-Altitude Flight

ENGINEERING

A NOTE in our September issue gave brief details of the record-breaking high-altitude flight, on June 30, 1937, by Flight-Lieutenant M. J. Adam in a Bristol airplane powered with a Bristol engine, and flown from the aerodrome at the Royal Aircraft Establishment, Farnborough. A description of how the difficulties of this flight were overcome was presented by A. Swan in a paper read before Section G of the British Association for the Advancement of Science on Sept. 6, 1937, to be found in the Sept. 10, 1937, issue of *Engineering*. With the paper was presented a table of world altitude records for heavier-than-air craft, beginning with that made by Latham in 1909, in France, with an Antoinette plane and engine, at which a height of 509 ft was reached, and ending with the present record of 53,937 ft.

In his paper Mr. Swan points out that the power per unit weight of aircraft which the engine must develop at ceiling, other factors assumed unchanging, varies inversely as the square root of the relative density of the atmosphere. This variation of power required with height is shown in curve *A*, Fig. 1, together with the probable relative power of a normally aspirated engine (curve *B*). For a ceiling of 54,000 ft the power required per unit weight of aircraft is approximately 2.8 times the maximum power necessary to maintain level flight at ground level. The required power at ceiling may be obtained either by maintaining ground-level power at low boost in an engine of comparatively low power-weight ratio to an altitude nearly approaching the ceiling (curve *C*), or by supercharging an engine of higher power-weight ratio to a lower altitude (curve *D*), and allowing the power developed to fall off during the subsequent climb from rated altitude to ceiling.

The Bristol Company's nine-cylinder radial air-cooled Pegasus engine, of the type used in the record flight, in its fully supercharged form, is fitted with a gear-driven centrifugal single-stage supercharger to enable more or less constant power to be maintained up to altitudes approaching 15,000 ft. For the record-flight it was decided that a rated altitude of the order of 40,000 ft would provide a suitable compromise between a high engine output per unit weight and a high overall compression ratio of supercharging plant. In order to obtain this rated height it was necessary to employ another supercharger in a two-stage combination, with an intercooler between stages, so that the temperature of the mixture entering the engine would not be excessive. This additional supercharger is also gear-driven from the engine and can be clutched in when required. The carburetor is placed between the two superchargers, and during take-off and the early part of the climb only one supercharger is in use, the air passing through the stationary auxiliary supercharger, the intercooler, and the carburetor, then the main supercharger, into the engine. The estimated brake horsepower of the engine at altitude, at maximum revolutions per minute, is given in Fig. 2, compared with the power developed by previous record-breaking engines of 1932 and 1936.

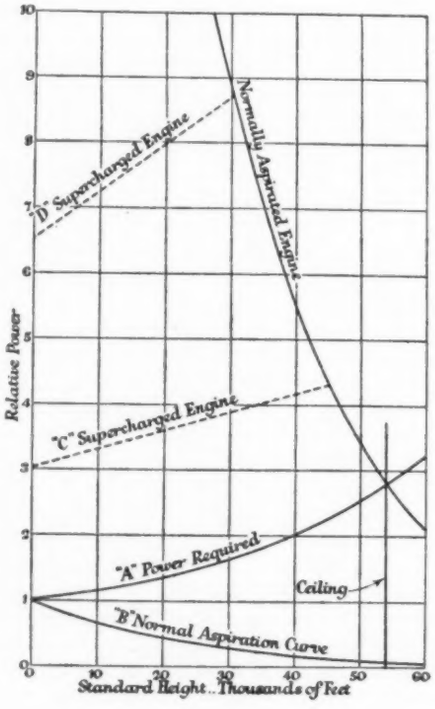


FIG. 1

Mr. Swan next gives details of the engine, the plane, the four-bladed, fixed-pitch propeller, the recording instruments, the flyer's suit, and the report of the flight.

Human beings, he explains, can breathe and live without discomfort at heights up to 15,000 ft. Above this height, the natural atmospheric pressure does not provide sufficient oxygen for well-being, so the resort has to be had either to increasing the percentage of oxygen in the air inspired or to increasing the pressure. The first of these methods becomes inadequate at altitudes exceeding approximately 43,000 ft. Above this height, therefore, it is necessary to increase the pressure of oxygen in the lungs, and this cannot be efficiently accomplished without balancing the pressure surrounding the pilot by a requisite amount. Two alternative methods are in use—the sealed cabin and the pressure suit. In the record flight the pressure suit was used. This was made of rubberized fabric in two pieces secured at the waist with a large double window in the helmet. Air which is dried in passing through a small drying canister is allowed to flow in and out of the space between the two windows in accordance with the pressure changes in the course of the flight, the purpose of this being to prevent misting of the window.

Flexible pipe connections are made from the helmet of the suit to points in the system to form a closed circuit. Carbon dioxide and moisture are removed from the exhaled breath by a chemical canister, and circulation is maintained around the system by an automatic injector fed through a reducing valve. The pilot is able to regulate the pressure by means of an inflation and deflation control.

The cockpit of the airplane is closed by a transparent hood and heated by air which enters ducts in the leading edge of the wing, then passes across the inner surface of the oil coolers, and is discharged, under the pilot's control into the cockpit.

Mr. Swan concludes by noting that a pressure cabin and suitable wireless direction-finding apparatus are needed for high-altitude flight. At present the perpetual good weather conditions of the stratosphere cannot be exploited because of cloudy weather in the troposphere.

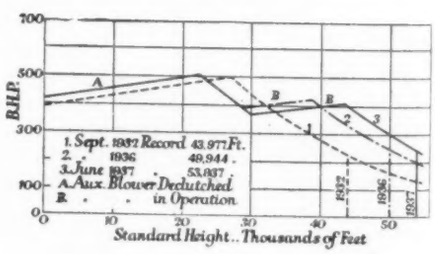


FIG. 2

Low-Temperature Carbonization

INDUSTRIAL AND ENGINEERING CHEMISTRY

ACCORDING to David Brownlie, who writes in *Industrial and Engineering Chemistry* for July, 1937, there has recently been a sudden new interest in low-temperature carbonization of bituminous coal in Germany as a result of the use of tar for hydrogenation and of the solid fuel for operating automobiles by means of producer gas. His paper gives briefly information on low-temperature carbonization of bituminous coal in Germany and Great Britain. Low-temperature carbonization is a somewhat vague term, but roughly it means the carbonization of bituminous coal, generally at about 900 to 1200 F, and almost always by methods different from those of high-temperature carbonization in gas retorts and by-product ovens. The result is a hard reactive smokeless fuel with about 10 to 12 per cent volatile-matter content, which is superior in general qualities to high-temperature carbonization coke, especially for domestic and other purposes including total gasification.

The main portion of the Brownlie paper consists of brief descriptions of the following low-temperature carbonization processes: B. T. or Brensotoff-Technik process, Berg process, Coalite process, Kollergas process, Krupp-Lurgi process, Morgan process, Otto process, Pintsch-Weber process, Pott-Broche process, Robinson Brindley process, Stephenson process, and Suncole process.

Cast Crankshafts

THE FOUNDRY

ENGINEERS who have habitually thought of cast iron as an unrelible, weak, and brittle metal have had to revise their opinion as a result of the recent growing use of cast camshafts and crankshafts by a number of engine builders. At a meeting, Feb. 9, 1937, of the Society of Automotive Engineers, Fred J. Walls presented a paper on cast camshafts and crankshafts, to be found in the March and April, 1937, issues of *The Foundry*, from which the following excerpts have been taken.

Engineering design may be considerably reduced in the casting process as compared to the forging process. Pattern costs, as a rule, will be several times less than the cost of a die, and in the case of new designs where changes are readily made while changes in dies are usually difficult, if not impossible to make.

Expensive forging equipment and heat-treating furnaces are not needed for cast materials. Reduction in machining costs made possible by the use of cast materials has been described in the literature quite extensively.

From the standpoint of economy the initial outlay is such that the engineer has been presented with possibilities which he has often dreamed of, but which could not be carried out in forging designs. By the casting process it is possible for him to locate his counterweights and control gravity centers at those points where his mathematical calculations show they should be placed.

Crankpins, bearings, and cheeks may be cored out, thus eliminating a great deal of unnecessary weight, which is often expensive to remove from a forging. By proper design this elimination of weight often increases the engine output by the reduction of physical forces.

The improvements in characteristics of cast materials through the use of alloys, metallurgical control of melting operations, improved molding conditions, and technical control in the foundry have taken the guesswork out of the casting process and made the uniformity of production more certain and dependable.

The physical properties which are so essential in cast cams and cast cranks may be summed up as follows: Rigidity, wear resistance, torsional strength, fatigue strength, and damping capacity.

There are several methods from a foundry standpoint which might be used in making cams, but the two most successful methods are differential hardening and controlled chill, both of which have been described in the literature quite extensively, but which may be outlined briefly as follows:

The first method was developed by the Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich., whose present daily production amounts to approximately 15,000 automotive camshafts of several different designs. After several years of experimentation the firm selected a composition as follows: Total carbon, 3.10–3.40 per cent; silicon, 2.10–2.40 per cent; sulphur, 0.10 per cent maximum; phosphorus, 0.20 per cent maximum; manganese, 0.50–0.75 per cent; chromium, 0.75–1.00 per cent; nickel, 0.20–0.40 per cent; molybdenum, 0.40–0.60 per cent.

This metal, called "Proferall" (processed ferrous-alloyed iron) is a duplexed cupola-electric-furnace iron having a Brinell hardness as cast in green sand of 262 to 293. Products are molded, usually four in a mold, on heavy molding machines at a rate of approximately 45 per hour (depending on size and number) in a mold placed on a conveyor, poured, and allowed to cool 45 minutes before they are shaken out and placed on another conveyor, to be taken to the cleaning room where they are shot-blasted, snagged, and ground.

When cooled to 150 F or less, they are given an impact test. Hardness on the gear blanks and bearings is checked, and file tests are made on the cams, after which the shafts are centered and straightened.

The hardening operation on the nose of the cams may be carried out by either the flame method or the high-frequency method. The principle involved is to heat the part rapidly to above the critical, and allow sufficient time for penetration of the heat to the desired depth. By rapid cooling a martensitic structure is obtained on the nose having a scleroscope hardness of 65 minimum.

The second or controlled-chill method was developed by Ford Motor Co., Dearborn, Mich., using an iron melted in the cupola having the following composition: Total carbon, 3.30–3.65 per cent; silicon, 0.45–0.55 per cent; manganese, 0.15–0.35 per cent; copper, 2.50–3.00 per cent, and chromium, 0.00–0.25 per cent. These cams are produced two in a mold in green sand without chills and are gated. The casting is mostly of gray iron with cam tips of white iron for a specified depth.

Accurate metallurgical control of the melting and pouring operations as developed by Ford metallurgists has made this method successful and economical. Adjustments in the composition of the molten metal are made at the cupola in 1000-lb ladles when necessary. This is determined by pouring $1^1/_4$-in. round test bars 6 in. long in dry-sand molds, breaking them, and examining the fracture.

Ferrosilicon or ferrochromium is added to decrease or increase, respectively, the chill depth on the nose of the cams, which must be held to within $^1/_8$ in. It is claimed that the high percentage of copper lessens the usual tendency of variable chilling capacities, and that a minimum amount of ladle doctoring is required because of its stabilizing effect. Rigid shafts without a measurable amount of wear are produced by this method.

In addition to the two methods already outlined, there are others that should be mentioned. One is the use of chills in

the mold, either rammed in or inserted in prints, to produce white iron on the cam lift and nose and a composition suitable to obtain gray sections in the parts requiring machining operations. This was the first method used in casting cams and is still employed where the quantities required by the customer are small.

Another method is to select an alloyed iron that will cast gray with good machinability and that will respond to quench hardening. This method is used in designs where susceptibility to warpage is not likely to be encountered. Air-hardening alloyed irons have been developed, and castings made of these irons are considerably less likely to warp as a result of lower differential temperatures.

Crankshafts have been made from all kinds of materials, both in the forged and in the cast form, but not until recently were the cast products considered safe for use in high-speed engines. The Ford Motor Co., after lengthy and costly experiments in the laboratory and in service, adopted an alloy cast-steel crankshaft. Between two and three million of these shafts have gone into service on Ford automobiles with a marked reduction in failures below those which previously were encountered with the use of forged-steel crankshafts.

The merits of the cast-steel shaft over the forged are said to be: (1) Economy of manufacture, because of eight fewer fabricating operations and the removal of 9 lb of metal as compared to 24 lb; (2) improvement in engine performance, as a result of a decrease in weight from 66 to 56 lb in the finished shaft and a lower coefficient of friction; (3) twice the resistance to fatigue failure, which is probably due to a much lower sensitivity to the so-called notch effect in the portions undergoing stresses.

The composition and physical properties of Ford cast alloy steel, which is melted in the electric furnace, are as follows: Total carbon, 1.35–1.60 per cent; manganese, 0.60–0.80 per cent; silicon, 0.85–1.10 per cent; chromium, 0.40–0.50 per cent, and copper, 1.50–2.00 per cent.

Heat-treatment consists of heating to 1650 F and holding for 20 min.; air quenching to a minimum of 1200 F; reheating to 1480 F, holding 1 hr; and cooling in the furnace to 1000 F in 1 hr. Physical properties after heat-treatment are: Tensile strength, 95,000 to 110,000 lb per sq in.; elongation, 2.5 to 3 per cent, and Brinell hardness 250–320.

At the present time nickel-molybdenum gray cast irons have been adopted as standard by seven manufacturers.

Flame Hardening

OXY-ACETYLENE TIPS

FLAME hardening, according to an article in the October, 1937, issue of *Oxy-Acetylene Tips* may be defined as a process whereby the surface of a general hardening ferrous material is locally heated by means of an oxyacetylene flame followed by a suitable quench. A hardened surface is thus obtained without altering the chemical composition of the material. The method combines the simplicity of hardening by heating and quenching, with the ideal features of the case-hardening processes, the production of a hard steel surface, and a tough ductile core. Parts may be hardened where hardness is desired, such as the teeth of gears, and the depth to which the surface is hardened may be controlled within reasonable limits.

The application of the flame-hardening process may be divided into four methods—stationary, progressive, spinning, and combination.

The stationary method includes those in which the blowpipe and work are motionless during the process, such as in the flame hardening of automotive valve stems, sometimes referred to as "spot hardening."

In the progressive method blowpipe and work move with respect to one another, as in the hardening of machine-tool ways. For flame hardening a plane surface the lighted blowpipe, with a head having sufficient flame area to cover the path to be hardened, is directed along the surface, and immediately behind it moves a spray or stream of water which progressively quenches the treated surface. In circular work of large diameter the most successful method is that of treating and quenching by one revolution of the part. As in straight-line operation the surface speed varies from 4 to 10 inches per minute.

When a circular path is to be hardened the part may be spun under the flames of one or more stationary blowpipes, quenching the heated portion while it is still spinning. Rotational speed, which is not critical, is usually about 100 rpm, but may vary from 80 to 120 rpm or more. When the diameter of the part is 4 in. or more, two or more blowpipes are necessary.

In the combination method progressive and spinning techniques are employed. It is applied to circular objects of such length that the blowpipe may traverse while the part is being spun.

Flame-hardening operations should be followed by a stress-relieving draw, shortly after quenching, in an oil bath or furnace. Drawing prevents checking, minimizes distortion, and, if conducted at temperature of 300 to 400 F, has little effect on hardness. It should take place within half an hour after hardening.

It is said that to flame harden 1 sq in. of steel requires about 0.25 cu ft each of oxygen and acetylene.

European Automotive Diesels

S.A.E. JOURNAL

SIX ESSENTIAL requirements for Diesel engines for automotive service are listed by H. R. Ricardo and J. H. Pitchford in a paper entitled "Design Developments in European Automotive Diesel Engines," to be found in the September, 1937, issue of the *S.A.E. Journal*. These are:

(1) The ability to operate over a range of speed closely comparable with that of an equivalent gasoline engine and therefore to compete closely with it on a power-weight ratio basis.

(2) Complete freedom from exhaust smoke or smell even under conditions involving long spells of idling and light running, as in dense traffic.

(3) Freedom from combustion noise, particularly when accelerating against load.

(4) Ability to use a type of injector nozzle not affected in its operation by the formation of carbon and hence one that need not be disturbed except at long intervals.

(5) Insensitivity to a large variety of fuels covering a wide range of ignition quality or cetane value.

(6) Ability to dispense entirely with any form of mechanically or manually operated timing device for the fuel-injection pump.

In discussing these essentials the authors point out, among other things, that at present the high-speed oil engine necessarily costs rather more than its gasoline equivalent, and a large proportion of this difference is represented by the relatively high cost of the fuel-injection equipment. This represents a cost per cylinder which is practically constant, irrespective of engine output, and may be as great as the cost of building the rest of the engine.

The importance of the smoke and smell requirement is great-

est when the engine is used in urban traffic. The authors say that with nearly 2000 oil-engine busses in the service of the London Passenger Transportation Board, and in spite of the increased volume of traffic of recent years, there has been, if anything, an improvement in the condition of the air at street level. They attribute improvement to the use of the swirl-chamber combustion system.

The authors feel that, although it is a little vain to hope for the compression-ignition engine ever to compare on even terms with its gasoline counterpart for smoothness and silence, much

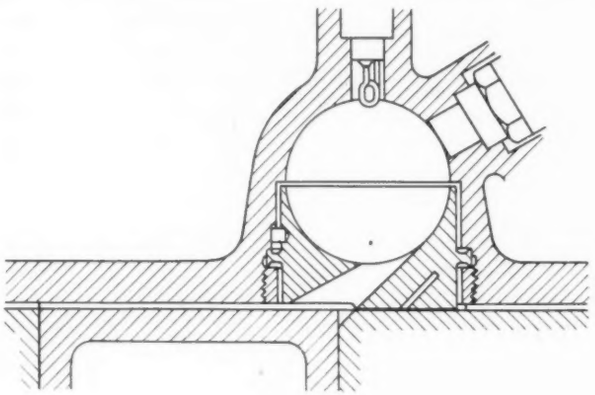


FIG. 3 COMPRESSION-SWIRL COMBUSTION SYSTEM

can be, and is being, done, apart from engine design, by attention to engine mounting and proper use of sound-absorbing materials under the hood and on other parts of the structure directly exposed to engine noise.

Apart from one or two outstanding exceptions, it is accepted among high-speed engine manufacturers in Europe that, for reliability in service, the pintle-type nozzle is second to none. The authors say that they have seen many nozzles of this type which have been in continual service for more than three years—some 180,000 miles—without more attention than routine cleaning and without reconditioning.

As to ability to make use of a wide variety of fuels, the authors point out its importance and devote a major portion of their paper to a discussion of various combustion systems in use in Europe today. Preference for the compression-swirl combustion system, shown in Fig. 3, is expressed by the authors.

Improved Chilled Car Wheels

STEEL

AN IMPROVED method of heat-treating chilled car wheels resulting in uniform strength increase is reported by S. C. Massari, metallurgist, Association of Manufacturers of Chilled Car Wheels, in the Aug. 23, 1937, issue of *Steel*.

The necessity for the heat-treatment of chilled car wheels, according to Mr. Massari, arises from two principal sources: (*a*) The total relief of internal casting stresses, so that the metal in the finished wheel possesses its full potential strength, and (*b*) a modification of the as-cast structure of the chill which will increase its resistance to impact failure and temperature gradients resulting from brake-shoe application. The internal stresses result from differences in cooling rates of the various parts of the wheel and the markedly greater shrinkage of chill as compared with mottled and gray iron. Under certain conditions internal stresses may be as great as 75 per cent of the ultimate strength of the metal. Since the chilled wheel is not at uniform temperature as it comes from the mold, it must be made so before any portion of it passes through the critical range as it cools in order to relieve internal stresses.

Investigations reported by Mr. Massari developed a heat-treating cycle which eliminated internal stresses and was accompanied by structural changes in the metal. In the as-cast condition the material of the chill consists of distorted lamellar pearlite which, after heat-treatment, is converted into a uniform type of structure, usually consisting of spheroidized cementite and ferrite. In the heat-treating process for stress relieving the first change in structure produced a straightening of the pearlite lamellae to provide a strain-free pearlite. By annealing to spheroidize the matrix of the chill completely further improvement resulted and greater uniformity of strength was obtained.

Following the laboratory experiments made by heat-treating more than 300 test specimens, then casting test bars and subjecting them to tests in a testing machine, and finally by casting and heat-treating 8-in. wheels, data were accumulated to serve as a foundation for final experiments on standard wheels. Using an electric heat-treating furnace, definite heat-treating cycles were investigated and the usual tests of the wheels were conducted. The investigation resulted in an increase of from 30 to 40 per cent and a uniformity in strength that the author claims was hitherto unattainable.

With the heat-treating cycle established, the research staff developed a unit type of pit, constructed of low-heat-capacity, low-thermal-conductivity refractories scientifically designed so that the sensible heat within the wheel at the time of shake-out is conserved and the subsequent temperature drop automatically regulated to a preestablished rate. Many of these parts are said to have been constructed and to be in successful operation at the present time. The type of pit construction produces a minimum temperature gradient between center and end of wheels in the same pit, requires no extraneous heat, and is said to be almost foolproof.

Wood Shrinkage and Swelling

INDUSTRIAL AND ENGINEERING CHEMISTRY

TWO PAPERS dealing with the problem of minimizing wood shrinkage and swelling are to be found in the July, 1937, issue of *Industrial and Engineering Chemistry*. The effect of heating wood in the presence of various gases (hydrogen, illuminating gas, air, oxygen), is considered by Alfred J. Stamm and L. A. Hansen. They point out that the hygroscopicity and subsequent swelling and shrinkage of dry wood are decreased by heating it in various gases above the thermal decomposition temperature. Greater reductions in hygroscopicity are said to be obtained in an oxidizing than in a reducing atmosphere for the same heating conditions, but by increasing the temperature equal reductions in hygroscopicity can be obtained in reducing atmospheres. The darkening of the wood on heating appears to vary directly with the resulting reduction in hygroscopicity, regardless of heating conditions. Soaking in water after heating has but a slight tendency to restore the original hygroscopicity. Heating wood in water-saturated atmospheres is said to have no permanent effect upon the swelling and shrinking.

The treatment of wood with sucrose and invert sugar solutions is discussed by Alfred J. Stamm, and it is said that this treatment greatly reduces subsequent shrinkage. Shrinkage takes place when the relative vapor pressure under which the specimens are dried is less than the relative vapor pressure of

the treating solution at the concentration attained when evaporation has proceeded to the fiber-saturation point. The large reduction in shrinkage to the oven-dry condition is the result of the deposition of sugar within the swelling structure. This reduction in shrinkage can be calculated from the partial specific volume of sugar in the concentration attained within the swollen structure, on the basis that this concentration becomes equal to the corresponding bulk concentration.

Invert sugar is said to reduce the dimension changes of wood to a greater extent than sucrose and should serve as a good antishrink agent under conditions that will not be too conducive to the leaching of the sugar from the wood.

Testing Deep-Drawing Material

MACHINERY (LONDON)

A MACHINE, developed by Georg Reicherter, Esslingen a.N., for testing the deep-drawing properties of materials is described in *Machinery* (London) for Aug. 26, 1937. The machine consists of two heads, one stationary and the other movable, between which the test piece is fastened. Fig. 4 illustrates the test piece used in its condition *A* before testing and *B* after testing. The tapered head of the test piece is drawn to a parallel form during the test as indicated in Fig. 4. Thus loads and strains are imposed on the test piece which are similar to those imparted to a blank in the actual drawing operation. The magnitudes of these strains, which are greater at the upper than at the lower end of the test piece, can be measured by inscribing equally spaced lines as shown in Fig. 4. The deep-

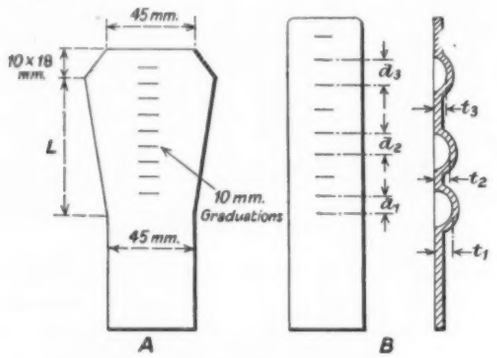


FIG. 4 TEST PIECE EMPLOYED
(Before (*A*) and after (*B*) testing.)

drawing quality is next tested at various points, and by comparing the measured value with the original value, it is possible to determine the reduction of the deep-drawing capacity as a result of the deformation the material has undergone and to express it as a percentage of the original capacity.

Fig. 5 shows some curves of the characteristics of a rolled material tested in the machine and subjected to different heat-treatments. The abscissas are the relative deep-drawing depths expressed as percentages of the original depth. Obviously Fig. 5 shows that material 4 is to be preferred for its deep-drawing characteristics to material 3, for example, as it will be able to withstand a sequence of operations without annealing.

In carrying out the test the sample is coated with a thin film of lubricant to prevent seizing and tearing. During the test the wedge-shaped piece is held in a head similar to that shown in Fig. 6. The head consists of a base member *A* and the side wedges *B*, the clamping key *C* being firmly tightened against

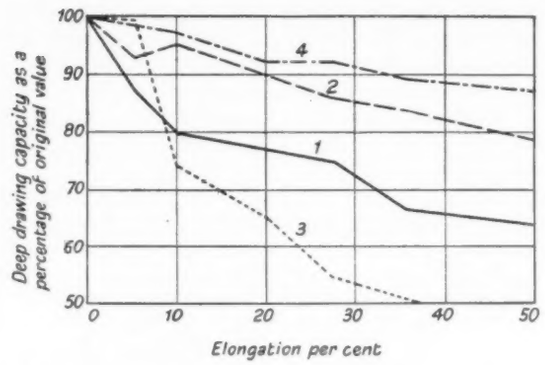


FIG. 5 CURVES SHOWING DEEP-DRAWING CAPACITIES FOR VARIOUS MATERIALS AFTER BEING STRETCHED BY VARYING AMOUNTS

the test piece by screws *D* in the cover plate *E*. The upper end of the head is adjustably mounted in a stationary holder bolted to the crosshead of the machine frame.

After the test piece has been prepared and clamped in the holder it is drawn in the usual way. The piece is marked with 10-mm graduations as shown in Fig. 4. The normal length of the standardized test piece is 72 mm. After the completion of the test the elongations are measured and then the usual deep-drawing tests are carried out. Thus, in Fig. 4 for elongations d_1, d_2, and d_3, the corresponding drawing depths are t_1, t_2, and t_3.

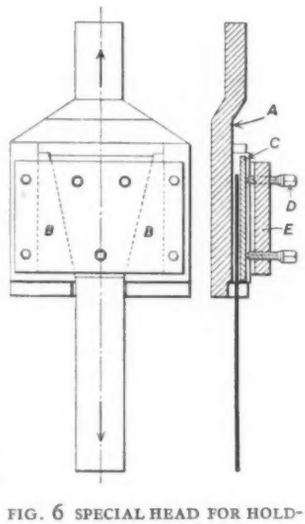


FIG. 6 SPECIAL HEAD FOR HOLDING TEST PIECE

Engineer as Employer

CIVIL ENGINEERING

SOME of the implications of the engineer's dual capacity as employer and employee are investigated by Louis C. Hill, president, American Society of Civil Engineers, in the September, 1937, issue of *Civil Engineering*.

Commenting upon the engineer's common complaint that the profession of engineering lacks recognition, Mr. Hill expresses the opinion that what is most generally referred to is the engineer's economic status, his material, and mundane reward.

To have a basis for action, he says, and at the same time to be frank with ourselves, we must accept the condition that engineers comprise fundamentally an employee group in which the world at large has the greatest confidence, but regarding whom the public has little individual concern. Going a little further, we must consider the significance of the unique fact that ours is the only profession in modern society which both works for itself and employs itself. Because of this anomaly, each engineer is in a great measure responsible for the status of his profession, both abstractly and concretely.

Paradoxical as it may seem, he continues, a large proportion of the engineers who are employees are at the same time em-

ployers of engineers. Particularly is this true of those in responsible charge of work. To the same extent that he is responsible to his superiors for the execution of engineering work done by his subordinates, the engineer in charge is responsible to his subordinates for any recognition or lack of recognition given them by his superiors.

So definite have become the demands for more effective action and more tangible results regarding the economic status of the individual members of the profession that quasi-technical organizations have been formed which have this improvement as their objective. Guilds and other associations are in existence for similar purposes which make no pretense of being technical in character, and in some localities the younger engineers and engineering aids have gone so far as to join militant labor organizations.

It should be obvious, says Mr. Hill, that this trend toward trade unionism, if permitted to continue, will destroy whatever standing the engineer has obtained as a member of an acknowledged profession. Hence, it is imperative that we consider what line of action is available to us other than the direct action of collective bargaining.

In Mr. Hill's opinion, the answer lies in recognition of the responsibility of each engineer to his subordinates. It means that engineers must assume, actively and individually, the obligation of the dual function of employer-employee and this involves real concern for the working conditions of these subordinates and for the monetary and other rewards that they receive.

Instead of accepting this responsibility as an individual, continues Mr. Hill, the engineer has generally shifted it to some organization with the hope that something would be done. When he did so, and failed to sell to his superiors the value of the services of his subordinates, he failed also in an obligation to the profession. Improvement in the social and economic status of members of the engineering profession can come as a result of our own individual efforts if every engineer will acknowledge this responsibility of the employee-employer relation, if he also accepts the obligation of this relationship, and if he makes that obligation the basis of his own professional action.

Science' Hair Shirt

THE SCIENTIFIC MONTHLY

IT IS well to be reminded from time to time that, in common with other social influences, with science we must expect to take the bitter with the sweet. That during the past century science has been successful as affirmed by A. S. Pearse in the October issue of *The Scientific Monthly*, few will deny. Yet the rewards of success, Dr. Pearse reminds us, are power, position, and hard work; not affluence and ease as the unsuccessful believe. The penalties of success are jealousy and responsibility. The tycoons of the earth are always the subject of green-eyed envy. They must care for the so-called unfortunate and tell them what to do. They are blamed for hard times, plagues, famines, hurricanes, and other "acts of God."

So it is with science. It is blamed by nonscientists for the troubles of society. Critics of science gleefully point out that scientific theories grow into dogmas which impede the progress of civilization, though scientists have worked for generations to explain natural phenomena. The world is still full of mysteries; though knowledge has increased enormously, man is still wicked. Perhaps the worse sin that science has perpetrated, Dr. Pearse asserts, is the giving to civilized man of comfort, convenience, and leisure, so that he does not have to think daily about how he is going to live through.

Theoretically, as Dr. Pearse points out, science can do no harm; its sole purpose is truth. But scientists are human. Science has not changed the nature of man or of their societies, but it is not the business of science to make man good. In this connection he quotes, A. G. Keller: "There is one common misconception about evolution, that it means progress. It means adjustment only." A man must adjust himself to society in the particular time and place in which he happens to be situated. Science is a product of modern civilization. It has been created by sweating, thoughtful men. Men are just human beings, and will be as long as civilization lasts. Science is truth, but its application is whatever men make it.

Vocational Guidance

OCCUPATIONS

INFORMATION for vocational-guidance counselors in two fields related to mechanical engineering—air conditioning and Diesel engines—is to be found in the June, 1937, issue of *Occupations*.

Writing on "Opportunities in Air Conditioning," S. Lewis Land, educational director of the National Association of Heating, Piping, and Air Conditioning Contractors, says that it is unfortunate that the belief exists that there are great opportunities for new manpower in the industry without regard for the background of training and experience.

The industrial market, he says, offers large possibilities both in existing and in newly constructed plants. Perhaps the largest volume of business, he continues, is in the commercial market—large public buildings, theaters, department stores, banks, office buildings, apartments, libraries, hospitals, schools, restaurants, and the like. The greatest potential market is the home field, but it is difficult to estimate accurately its immediate, or near-future, demand.

While the author does not subscribe to the belief expressed by some that air conditioning is a five-billion-dollar industry, he admits that there are large potential opportunities for the young man who will attempt to prepare himself in any one of the three major divisions of the industry—manufacture, distribution, and installation.

In the manufacturing field there is need for the highly trained engineer and the specialist in merchandising, and for the various classes of mechanics engaged in the manufacture of the wide range of apparatus which go into a complete air-conditioning installation. In the distribution field there is need for dealer-salesmen, engineers, and specialists in advertising. The installation division of the industry calls for the services of two types of skilled mechanics—steamfitters and sheet-metal workers. In the same field the demand for estimators, draftsmen, and engineers will increase as volume increases.

The author states that there is little adequate information concerning occupational opportunities in the air-conditioning field, but a footnote remarks that the National Occupational Conference is preparing an abstract and appraisal of available literature on occupations in the field, which should be ready for distribution soon.

With respect to the Diesel-engine field, the same issue of *Occupations* contains two articles, one by Ralph D. Fleming, "The Facts About Diesel Engine Careers," the other by Robert Hoppock and Samuel Spiegler, "Diesel Engine Occupations," an appraisal and abstract of the literature, with bibliography.

Mr. Fleming says that public interest in recent applications

of Diesel engines, particularly in the field of transportation, have been seized upon and exploited by some schools for the purpose of creating the impression that the Diesel engine offers untold opportunities. Prominent Diesel-engine manufacturers were queried by New York State's Bureau of Vocational and Extension Education, and Mr. Fleming's article is based largely on their replies. In summary Mr. Fleming states that from an analysis of the opinions expressed no short-cut road via the Diesel schools to attractive jobs and large earnings is to be found. As in other fields of endeavor, there are opportunities for adequately trained, intelligent, and industrious young men. But there is almost universal agreement among the manufacturers that even the best of Diesel schools can offer to their graduates only the prospect of job status and earning capacity common to skilled occupations in related fields.

It will be remembered that F. G. Hechler came to a similar conclusion in his paper, "Diesel Engineering Instruction," published in the October, 1936, issue of MECHANICAL ENGINEERING. Professor Hechler's paper is one of the 37 references of the bibliography that concludes the article by Messrs. Hoppock and Spiegler. In their appraisal of the literature these authors conclude that some impartial, objective, and thorough-going investigations of employment opportunities in the Diesel-engine field are badly needed. One common element of all applications of the Diesel engine, they observe, is newness, and this factor suggests both the advantage of a field with almost unlimited possibilities of expansion, and the disadvantages of sharing with all novel enterprises a large element of uncertainty.

Looking for a Job

JOHN WILEY & SONS INC.

AS DIRECTOR of technical employment and training of the New York Telephone Co., Howard Lee Davis has had an opportunity, as well as a need, for studying the successful technique employed by men seeking work. He has set down his personal views resulting from this study in a little pamphlet, "Preparation for Seeking Employment," published by John Wiley & Sons, Inc.

Fundamentally, seeking employment, as Mr. Davis states in his foreword and emphasizes on almost every page, is a problem of salesmanship. Hence the person in search of a job must understand first what he has to sell—his own abilities and qualifications. This then, is the first step in the method of preparing to secure satisfactory employment put forward by Mr. Davis: You should study yourself. Other steps follow naturally. Determine where the preferred type of work is done; select a few concerns doing it; learn something about the first concern applied to; and finally secure the opportunity to make a personal application for employment. According to Mr. Davis, applicants for jobs give evidence in general of little or no preparation, and this leads him to discuss the question, Why do employers hire men and women? He next tackles common objectives made by seekers of employment to the method he proposes and gives examples to prove that preparation pays. Then follow sound bits of advice on seeking a specific interview and conducting oneself during the interview, on the application blank that may have to be filled out, on letters of application, on self-analysis and the recording of the results, and on references.

Perhaps the essence of Mr. Davis' advice is summed up in the following quotation: Prepare—Prepare to seek employment. Prepare for every big decision in life. Prepare generally so you can handle conditions as they arise. And you may be very sure that they will arise. Thus you will develop your entire self. Then you will have "knowledge" and you will have "wisdom." With these you can reach judgments that are founded on understanding.

Technological Education

THE SCIENTIFIC MONTHLY

WITH the admission that he exposes himself to the well-known hazards of the prognosticators, Karl T. Compton, president of the Massachusetts Institute of Technology offers, "A Forecast of Technological Education" in the October issue of *The Scientific Monthly*.

The progress of civilization, says Doctor Compton, may be measured by the trend from superstition to science in forecasting, but this trend has been immensely more rapid in some fields than others. Astronomers can predict an eclipse with stop-watch accuracy a century in advance; psychologists have made at least some progress in ability to forecast probable success in different occupations by measuring students' aptitudes; medical men are as yet powerless to foretell when or where the next epidemic of infantile paralysis will break out. All grades of forecasting, from hocus-pocus and racket to art and science, coexist as part of man's struggle for a more satisfying life.

Briefly summarized, Dr. Compton's views on the characteristics of technological education in the future are as follows:

The importance of technological education will increase. There will be increasing differentiation between the engineering school and the trade school.

Large industrial units or associations will increasingly establish their own trade schools to train expert technicians for their own special purposes.

Undergraduate curricula in technological schools will increasingly avoid specialization except in rather general fields, and will devote increasing attention to physics, chemistry, and the general principles and methods of engineering with supplementary education in social science and in the art of exposition. As a corollary the increasing need for technician specialists will be met by the graduate curricula and we may expect a continuation of the growing emphasis on graduate study.

We will see increasing differentiation in scope and more logical adaption to environment in our colleges and universities, with the result that many smaller or less favorably situated institutions will drop their ambitious attempts to encompass the whole field of education and concentrate their resources to do the best possible job as an undergraduate or junior college. The higher ranges of education will be concentrated in the most favorably situated institutions, and a few of these will emerge as superprofessional schools with the graduate aspect strongly emphasized. Research will become a continually more important activity in the leading technological schools.

Dr. Compton closes his analysis by discussing briefly the important question: Will increasing taxation and other methods of forcibly distributing wealth so cripple private philanthropy in this country, as to sound the death knell of the privately supported educational institutions, leaving all education in the hands of the state? In his opinion, if this should happen, education would be a major loser in the general catastrophe. However, he does not believe that the basic sense of the American people will let this happen. In conclusion, he states that the criteria for survival of a private institution will be that it offers a quality of education and public service superior to that obtainable in government-operated institutions.

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers in Previous Issues

Engineers and Security Issues

To the Editor:

The article by A. I. Henderson[1] interested me greatly. Mr. Henderson's argument that certain things must be done now agrees in several respects with that which I advanced in an earlier article.[2]

The difference in the philosophy of the lawyer and the engineer is obvious from various remarks that Mr. Henderson makes. The lawyer's reputation depends in considerable degree upon his ability to place his client's problems in the best possible light. My reputation as an engineer depends upon my ability to point out objectionable operating conditions, to foresee developments in machinery and equipment that are just around the corner, and show how better labor conditions are possible or how costs can be reduced. If I am to do these things properly, mincing words is often impossible. Past troubles in the investment field have arisen all too frequently from the failure of engineers to express their honest beliefs without equivocation. The lawyer, however, tries with diplomatic language to help his client get certain results such as a new bond issue. A report from an engineer that a new boiler plant is needed at a cost of about $500,000 for the company involved in the bond issue is one of those upsetting things in an expert's report that makes trouble for the lawyer in his use of language. Yet the investor is entitled to know that fact. Facts glossed over, as Mr. Henderson says, will cause the most trouble for executives and engineers and make more work for their lawyers. Knowledge that certain facts exist is more than half the battle in finding a way to overcome them. Executives and lawyers who resent the presentation of facts, uncomfortable as they may be, are in the same class with the ostrich who buries his head in the sand.

One of the most vulnerable spots in the work of engineers in connection with security issues is in the appraisal field. All too many appraisals still are being made without sufficient allowance for obsolescence. Such allowances cannot be made for the usual appraisal fee and frequently involve an expert study of some magnitude. Yet too often industrial or public-utility property is valued on the basis of replacement cost with a deduction for observed depreciation without recognizing that a new and better plant could be built for less than, or not much more than, the depreciated cost of the existing property. A chemical plant using a large quantity of process steam from 150-lb boilers and buying considerable electricity for lighting and power has no right to go to the public for financing without saying that a new boiler plant at 600 lb and turbogenerators, from which steam could be bled for process purposes, would cost $500,000 and pay for itself in three years. Yet equivalent things are being done today in connection with security issues. The day of reckoning in the courts for engineers and executives who are parties to such things is coming as certainly as lack of water in a boiler will cause it to blow up.

I hope that the day of the courageous, independent engineer is returning. The Securities Act will place a premium on his services. Considerable work has gone in the past to engineering corporations or engineers which may in the future go to a more independent type of engineer. Too many engineering reports have been written with an eye to the sources from which payments were to come. The engineers who wrote them depended upon volume business from large corporations. They could not afford to antagonize the head of one large corporation with an unfavorable report since their reputation as "unsafe" would spread rapidly to other corporations and volume business would be lost. This condition is still true because the report that is favorable to the client and makes the lawyer's work in connection with security issues easier is in demand. The security holder, however, will discover in a few years that such partisan engineering reports are vulnerable, and a few jail sentences and damage suits may result. Then the independent engineer who has the courage of his convictions and who will not rewrite a report to meet his client's views will come into his own.

Gregory M. Dexter.[3]

[1] "The Engineer and the Issue of Securities," by A. I. Henderson, Mechanical Engineering, August, 1937, pp. 595–600.

[2] "An Engineer's View of Investment Banking Reforms," by G. M. Dexter, Mechanical Engineering, May, 1933, pp. 275–278, and June, 1933, pp. 352–354.

The First Transatlantic Flight

To the Editor:

I have just read your editorial "A Smaller World" in the September number of Mechanical Engineering and shall be glad to know why you, and Americans generally, ignore the earlier flight of Alcock and Brown across the Atlantic in June, 1919, just after the war and in a war machine, a Vickers-Vimy bomber.

That flight really showed the way and all the later flights across have followed the same route they used. Those two men had none of the advantages of the later designs in airplanes and instruments that the later aviators have had available. In fact, my son was at home nearly a month making suitable apparatus and charts to enable him to take observations and determine the position of the plane immediately, as no suitable apparatus or charts were made at that time and it was impossible to adopt the leisurely methods employed on shipboard.

If you had known the machines and instruments available at that time, ideas and statements regarding spectacular flights that were made many years later would be greatly revised. The first flight across was made nearly all the way in a fog but it was successfully made in less than 16 hours. They had to climb many thousand feet twice to get observations of the stars, and twice got into a spin that nearly wrecked them because they could not get a horizon in the fog to enable them to tell when the plane was flying level. A few years later instruments were in use, long before any others made the crossing, which would have shown at once what was occurring.

[3] Engineering associate on management reports, Bitting, Inc., New York, N. Y. Mem. A.S.M.E.

It has seemed curious to me that the first flight across has been so utterly ignored in America and I haveoft en wondered why.

A. G. BROWN.[4]

Industrial Bearing Design

TO THE EDITOR:

I take exception to Mr. Willi's statement[5] that babbitt does not bond well to cast iron. Babbitt is readily bonded to machined steel because it has a denser grain structure and is more easily cleaned with acid. Surfaces to be bonded must be clean and dry. Also, the temperature of the piece should be elevated, never cold, when applying babbitt. In machinery today, considerable babbitting is done on iron which has only been sandblasted or pickled, not machined. Many times, due to the bulk of the base, or part, the babbitt is poured against the cold, unmachined iron, and no fusing is accomplished. Due to the fact that certain depressions, such as slots, splines, and the like, are placed in the casting to effect a squeeze anchorage, the nonfused portion flexes under shaft movement, and the babbitt breaks from fatigue. Had the housing been machined, cleaned, and heated before fluxing and then babbitted, the results would be comparable to that obtained in babbitting steel. These points are mentioned only to show why a bond on cast iron is not obtained as easily as with steel. However, neither bonds with babbitt as readily as does bronze, which has an affinity for babbitt and produces a slight alloying effect.

The author speaks of the thickness of the babbitt lining in early times as being needed to provide a mechanical anchorage. True, dowels and slots were used, but wear was expected. Shims were used to allow a possible $\frac{1}{8}$-in. take up on the diameter but not to the point of shaft and bearing contact. As for control of the babbitt structure with a straight-pouring method and a limited selection of babbitt compositions, their only possible control was preheating, cleaning, tinning, and pouring temperature. In many cases, this practice was adhered to, and reasonable results were obtained. Today, we know its importance, and it is a standard procedure.

Resistance of the babbitts to deformation goes up as the lining thickness goes down. The real limitation on the load-carrying ability of the babbitts is, either frictional temperature produced by load and speed, or surrounding conditions causing a temperature rise to the point of softening. This is, of course, exaggerated if the imposed load is a shock.

Unfortunately, bearing failures occur for reasons beyond the control of designers and manufacturers. A removable bearing has an economic advantage, if well-designed and installed, and will approach what is desired. A removable bearing, made as a babbitt die casting, is not adequate for most applications, because excessive wall stock is needed to produce strength for manufacturing, stocking, and assembling. This heavy wall reacts against the life of the bearing, because of its inability to carry loads at elevated temperatures. Even though the die-casting method produces a denser structure, its temperature resistance remains unchanged.

Bronze-backed, babbitt-lined bearings approach what is desired because a properly selected bronze alloy for the backing has an affinity for babbitt, and a bond between the two is more readily obtained. Alignment is assured when bored or line-reamed in place, and a thin section of babbitt lining is left to carry the load. I say bored in place, as this operation corrects all errors, which must, of necessity, creep in.

I am not adverse to the precision type of insert. As a matter of fact, I am highly in favor of it under certain conditions, but it is not a cure-all, so I am going to take issue against it for that reason. This type of bearing came into general acceptance for crankshaft bearings, as the author says, in 1926, because we had been stepping up the speed and horsepower of engines with approximately the same size crankshafts, and deflection was beginning to take its toll of the bearings. Builders of this style of bearing presented to the industry a way out for the moment. At this time, main-bearing wall thicknesses were approximately $\frac{1}{8}$ in. The precision-type bearing could have a wall of $\frac{1}{16}$ in. Holding the hole in the block to the same dimensions, thus permitting a change to be made without scrapping patterns, and truing up the holes by precision borings, allowed an increase of $\frac{1}{8}$ in. in the crankshaft diameter. I do not need to emphasize what $\frac{1}{8}$ in. on the diameter of a crankshaft will do for us. Besides, we save two operations on the assembly line, and, as this was a good engineering and economical move, the precision-type bearing was adopted. We must remember, however, that an engine is a compact, close-coupled, integral, and rigid casting, and, at least in theory, easy to hold main-bearing alignment.

Consider a removable liner with a wall thickness of 0.065 in. and a tolerance of —0.00000 and +0.00025 in., and a shaft of 2.000-in. diameter with a tolerance of —0.0000 and +0.0005 in., and, with the bore of block for the liner off the center line 0.0005 in. in $24\frac{3}{4}$ in. The clearance at the upper corner of the bearing at the extreme end of the shaft is 0.00025 in. If the high limit of shaft and liner were used, this clearance would be —0.00025 in., the shaft would be pinched, and the bearings would have to be run in until the babbitt lining was displaced and all bearings would be supporting the shaft. The service problem, in so far as the actual installation is concerned, has been alleviated, but alignment and running clearance are not assured. In so far as clearance would be concerned, if one or more bearings failed, the remaining ones would have been reduced slightly in thickness, and, consequently, even if a standard liner were installed, it would be higher, and all the load would be taken until its height was reduced. If the mechanic chose to use an oversize bearing, he would have to scrape, to level bearings, or this condition would be exaggerated.

The author states that modern engines equipped with this precision type of bearing are successfully functioning with maximum loading. This is reasonably true because in the manufacture of this type of bearing, extra care is taken to hold tolerance and effect bonding on a reduced thickness of the babbitt or lining material used, and also to demand round holes in bearing backing or supports.

Design of the lubricating system to effect greater coverage of the bearing areas has been partly responsible for the increased carrying ability of the bearings. Additional work along this line is needed. Another aid to carrying capacity has been more effective cooling, as inside engine temperatures have been materially reduced.

The author illustrates many types of precision bearing, and his company must be complimented on the high degree and quality of its product.

Centrifugal casting or spinning mentioned by the author came into general use about 1921, but much has been learned since then about the necessity of controlling the factors on which the success of the final spinning depends.

The author states that cadmium-silver and copper-lead bearing materials are applied only to steel backs. Could not cadmium silver be applied to some of the

[4] Browns' Dryers, Ltd., Manchester, England. Life Mem. A.S.M.E.

[5] "Automotive Practice Influences Industrial Bearing Design," by A. B. Willi, MECHANICAL ENGINEERING, May, 1937, pp. 321–325.

nonferrous alloys, and, if copper lead is needed for a lining in the steel-backed bearing, might not the entire bearing be made from the one alloy?

The statement that tin-base babbitts do not bond well with cast iron and that certain bronzes require careful treatment to effect a solid bond is repeated and the author adds that the thickness of the babbitt bearing is generally $^1/_8$ to $^3/_{16}$ in., and a mechanical anchorage is required. He also states that, with a steel- or bronze-backed bearing, dependable bonding with approximately $^1/_{32}$ in. of babbitt is obtained and no anchorage is needed. Is it the precision type of bearing or the $^1/_{32}$-in. thickness of the babbitt that produces this ease of bonding?

A typical bearing problem is shown by the author in the upper drawing of Fig. 6. Comparable bearing failure exists in many types of machining today, and a change to a removable bearing would be of material benefit in increasing bearing life and reducing repair costs, both in dollars and cents and time lost. This condition is true whether the bearing is of the precision type or line-bored or reamed in place. Scraping is not recommended, because height cannot be controlled. For instance, if a chain of bearings support a common shaft and one or more fail, the remaining bearings are affected, and, unless the replaced bearings are the same height, they either support the whole load or fail to support any load. This is also true where one precision bearing is installed or replaced by a new bearing to original factory-equipment height, and I take exception to the precision-type bearing for that reason.

The author mentions a case in which a bronze eccentric rod operated on a steel shaft with rapid wearing of both parts.

If the alloy used in the rod was suitable for bearing use, the failure was caused by loss of the oil-film separation between shaft and rod, probably the effect of an out-of-round condition of the bearing end of the rod or bearing cap, a condition that had to be corrected when the removable liner was used.

The bronze bearing alloys that are used for backings on precision-type bearings and for which analyses are given in Table 3 agree generally with common practice but to these should be added S.A.E. No. 660, which type of alloy has rapidly advanced in favor in the last ten years, because of its good general bearing characteristics, conductivity plus added impact strength, which is desirable in flanged work. My findings on load-carrying capacities and characteristics of the alloys specified for special installations agree, but I wish to add to them the possibilities presented by sand-cast high-lead bronze bearings. I heartily agree with the author that bearing manufacturers should be consulted before specifying bearing type or alloy, as many factors that have a direct bearing on the life of the bearing are involved. Bearing manufacturers maintain an engineering staff for the benefit of their customers, and they should be consulted in design and material specifications. Machinery builders will save money in design by so doing and have fewer bearing failures.

The author describes, and shows in Fig. 8, the elements of a plain unflanged bearing, dimensions and tolerances of which he has established. Obviously, if bearings are to be used without treatment in place to produce a final clearance within limits between bearing and shaft even if the component parts are held to close machining tolerance, they much be nearly perfect, which, of course, is not reasonable. The bearing manufacturers must have tolerances, but as I have already pointed out close tolerances are essential. In setting up these manufacturing tolerances for the bearings, which can be held on precision production equipment, the author is approaching the ideal.

Babbitt-thickness values are given in Table 4, and the author says that thicknesses less than these have been used but ailments have led to the conclusion that, in cases where the bond may be slightly imperfect, added bearing life may be obtained by increasing the babbitt thickness. First, he decreases the babbitt thickness to get a perfect bond, then, when he does not achieve his objective, he increases it. Bond is a product of material and procedure, not dimension. Babbitt may be too thick to support the load or too thin to allow for the abrasives that are constantly being pumped across the bearing areas. In addition to the material and rigidity of the case, speed of shaft and type of load must be considered in selecting the material for the bearing back and determining the thickness.

Tolerance or wall thickness of 0.00025 in. for bearings 4 in. or under in diameter is reasonable and can be held on precision equipment, but designing engineers should not specify this tolerance for bearings that are to be treated in place. I bring this point up now, because it is happening every day, and the customer pays the bill.

Spread of the bearing half at the parting line is extremely important to prevent shaft pinch, and mechanics should be cautioned to see that this spread is present on assembling. The principle of the locking lip is recognized as a standard. I prefer the formed-radius type, because it does not leak through to the bearing back, or the shim type as shown by the author. Side reliefs are an absolute necessity. Here, I prefer a chamfer on each side of the parting line, so that a pocket or sump be formed for the oil. On methods of bearing location and retention, the author and I are in accord. Too little attention has been paid to this feature by designing engineers, and short-lived bearings have been the result.

ROBERT G. N. EVANS.[6]

[6] Bunting Brass & Bronze Co., Toledo, Ohio.

Byron Co., N. Y.

Normandie ENGINE ROOM LOOKING FORWARD AND STARBOARD
(To which an excursion is planned during the A.S.M.E. Annual Meeting. See page 872.)

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Recollections and Reflections

RECOLLECTIONS AND REFLECTIONS. By Sir J. J. Thomson. The Macmillian Company, New York, N. Y. Cloth, 6 × 9 in., 437 pp., 10 illustrations. $4.

REVIEWED BY G. B. PEGRAM[1]

IN the first line of the author's preface he refers to having "rashly consented" to write this book. Whoever it was that secured this consent did a fine service to a wide range of readers. Most of the book is informal and easy, conversation such as a sympathetic visitor to Sir J. J. and to Cambridge might be privileged to hear from his lips if he were asked about his early schooling, his student days at Owens College and at Cambridge, his professorship at Cambridge, his colleagues, his students, his researches, his visits to America, about the war years, about science in England, and about the part that the Cavendish Laboratory and the men who have studied there have played in scientific discovery. The final chapter "physics in my time" is of necessity a little more formal but makes no attempt to be a condensed treatise. Rather it gives brief stories of some of the more important discoveries of the period, with pertinent items relating to the discoverers and others.

These "Recollections and Reflections" can be enjoyed by a reader who has no especial interest in science or Cambridge University. The author claims in the preface that his memory "has always been very patchy, good for things which are amusing, bad for those which are instructive." This does not tend to dullness. Anyone who has any sympathetic contact, intellectual or otherwise, with Cambridge University, or anyone who wishes to know better a great leader and teacher for more than fifty years in the science of physics, or anyone who is interested in scientific education and research, will read this book with very special satisfaction.

The Recollections begin with the writer's early days in a suburb of Manchester, then pass to his student days at Owens College, new and small, but having on its staff at that time men who gained such distinction as Lord Bryce, Osborne Reynolds, Balfour Stewart, Stanley Jevons, Adolphus Ward, and H. E. Roscoe. Like numerous others, young Thomson turned from engineering to physics, in his case from lack of money to pay for the engineering apprenticeship which would follow the three-year college course. He stayed at Owens by winning scholarships and when 20 years old won scholarships at Trinity College, Cambridge. At Cambridge, Latin, Greek, mathematics, and physics occupied Thomson as an undergraduate. He was influenced by eminent teachers, and especially by the great "coach," Dr. Routh, whose pupils took first place, the Senior Wranglership, in the Mathematical Tripos or Honors Examination at Cambridge for 24 out of 33 years and who "coached" not by any individual instruction but by "a series of exceedingly clear and admirably arranged lectures" before a class.

A paper on a general method in thermodynamics won him a fellowship at Trinity College, after which in 1880 began his series of mathematical investigations on the theory of moving electric charges, and some experimental work in the Cavendish Laboratory, which had opened in 1874, the second university research laboratory for physics in England.

A good portion of the book is naturally given to the story of the work of the author and others in the Cavendish Laboratory, and there are in this part as elsewhere valuable "Reflections" as well as Recollections. Some experiences in psychical research, and remarks on telepathy and water dowsing have a chapter. Visits to America, Canada, and Germany and to Princeton, Johns Hopkins, Yale, Harvard, and Bryn Mawr are given their place. War work of the Board of Invention and Research of the British Navy has a chapter in which Lord Fisher is prominent. "Some Trinity Men" gives little intimate sketches of colleagues at Trinity. Dr. Butler, master of Trinity, Henry Jackson, professor of Greek, Henry Sidgwick, the philosopher, A. E. Housman, the poet, and numerous others appear here.

"The Discovery of the Electron," perhaps the most notable single feat of Thomson, is related in its proper setting.

"Recollections and Reflections" is not a "solid" work, nor is it heavy. It is a record, a lively, human, and valuable one, of a life of scholarship and research, of a great university, and of an epoch in physics.

[1] Professor of Physics, Columbia University, New York, N. Y. Mem. A.S.M.E.

Books Received in Library

ALLOYS OF IRON AND CHROMIUM. Vol. 1, Low-Chromium Alloys. By A. B. Kinzel and W. Crafts. Published for the Engineering Foundation by the McGraw-Hill Book Co., New York, 1937. Cloth, 6 × 10 in., 535 pp., illus., charts, tables, $6. This latest addition to the valuable monographs issued by the Alloys of Iron Research is the first part of a review of the existing information on these alloys. It is restricted to the constitution and structure of the iron-chromium and iron-chromium-carbon alloys, and the properties of steels and cast-irons containing less than ten per cent of chromium. A bibliography of 478 items is included. In addition to reviewing the published data, some recent unpublished information has been incorporated in the text.

A.S.T.M. STANDARDS ON PETROLEUM PRODUCTS AND LUBRICANTS, prepared by Committee D-2 on Petroleum Products and Lubricants, September, 1937. Published by the American Society for Testing Materials, Philadelphia, Pa. Paper, 6 × 9 in., 390 pp., illus., diagrams, charts, tables, $2. A compilation which brings together in convenient form the 1937 Report of the Committee on Petroleum Products and Lubricants, the various A.S.T.M. standard and tentative test methods pertaining to petroleum, and the regulations and personnel of the committee.

Berichte des DEUTSCHEN AUSSCHUSSES FÜR STAHLBAU, Ausgabe B, Heft 8. VERSUCHE ÜBER DEN EINFLUSS DER GESTALT DER ENDEN VON AUFGESCHWEISSTEN LASCHEN IN ZUGGLIEDERN UND VON AUFGESCHWEISSTEN GURTVERSTÄRKUNGEN AN TRÄGERN, by O. Graf. J. Springer, Berlin, 1937. Paper, 8 × 11 in., 16 pp., illus., diagrams, tables, 3.60 rm. A report of the German Committee on Steel Construction, describing experiments on the influence of the shape of the ends of welded fishplates in tension members and of welded-flange reinforcings for girders. The plan of the work, the construction of the test materials, and the method and results of the tests are explained.

BEIHEFTE ZUM GESUNDHEITS-INGENIEUR, Reihe 1, Heft 36. Die heiztechnischen Neuanlagen des Städtischen Krankenhauses Bad

Cannstatt, by H. Wolfer. R. Oldenbourg, Munich and Berlin, 1937. Paper, 9 × 13 in., 24 pp., illus., diagrams, charts, tables, 4.80 rm. This brochure describes the power plant of a large German hospital and reports the results of an operating test. The test sets forth in detail the consumption of heat, water, gas, and electric current by the hospital.

BOILER FEED WATER TREATMENT. By F. J. Matthews. Chemical Publishing Co., New York, 1937. Cloth, 5 × 9 in., 256 pp., illus., diagrams, charts, tables, $5. The book is divided into sections dealing with the principal operating problems separately; scale formation, corrosion, etc. The object is to present in collected form information of value to the small operating engineer who must handle his own problems.

DIESEL ENGINES. By P. E. Biggar. The Macmillan Co., Toronto and New York, 1936. Cloth, 6 × 9 in., 165 pp., illus., diagrams, charts, tables, $3.25. Condensed information in the Diesel field covering many particular points. The subject matter takes in historical material, an explanation of the operation of the Diesel engine and of its characteristics, advantages, disadvantages, special problems, and the probable future development of the Diesel type.

ENGINEERING MECHANICS, DYNAMICS. By S. Timoshenko and D. H. Young. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 323 pp., diagrams, charts, tables, $2.75. An elementary textbook on dynamics intended to give the student a thorough grounding in fundamentals. The choice of material has been made with the object of acquainting the student with many general methods of attack, and to illustrate the application of these methods to practical engineering problems. Three phases of the subject not usually contained in elementary books are covered: Vibration problems, elliptic harmonic motion, and relative motion. This material, however, may be omitted without producing discontinuity in the text.

ENGINEERING MECHANICS STATICS. By S. Timoshenko and D. H. Young. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 10 in., 334 pp., diagrams, tables, $2.75. A textbook intended to give a thorough grounding in statics for an engineer in any line. Subjects belonging more properly to strength of materials courses have been omitted. The general considerations are of plane forces, space forces, and the principle of critical displacements, practically illustrated with reference to trusses, joints, etc.

LA FATIGUE DES MÉTAUX. By R. Cazaud and L. Persoz. Dunod, Paris, 1937. Paper and cloth, 7 × 10 in., 190 pp., illus., diagrams, charts, tables; paper, 75 fr.; bound, 95 fr. This monograph analyzes the principal studies of the fatigue of metals and presents the results in form for use by engineers and metallurgists. The theories of fatigue in metals, methods of testing, fatigue limits, the factors that affect fatigue and the resistance of welded and riveted joints are discussed. Bibliographies accompany the various chapters.

GASES AND METALS. By C. J. Smithells. John Wiley & Sons, New York, 1937. Cloth, 6 × 9 in., 218 pp., illus., diagrams, charts, tables, $4.50. The three main types of behavior of gases and metals in contact are presented: adsorption, diffusion and solution. The discussion is concerned only with the general principles underlying equilibria between gases and metals and not with practical applications.

GRUNDSCHWELLEN, eine Massnahme gegen Wasserspiegel- und Sohlensenkungen. Untersuchungen aus dem Flussbaulaboratorium der Technischen Hochschule Karlsruhe. By H. Straub. R. Oldenbourg, Munich and Berlin, 1937. Paper, 8 × 11 in., 64 pp., illus., diagrams, charts, tables, 5.20 rm. This report, which emanates from the hydraulic laboratory of the Karlsruhe Technical High School, is a study of flow over sills and the effect of sills upon stream beds. The report gives the results of extensive model tests with stationary and moving stream bottoms, together with the results of experience with sills in rivers. The influence of various arrangements of sills upon erosion was determined.

THIS MONTH'S PAPERS *and* AUTHORS

VARIETY in a publication program makes for general interest, and variety is certainly a feature of this month's subject matter. Moreover, there is a variety of appeal to readers in all stages of professional development from the engineering student to the specialist. Even the picture-minded should be pleased and led to discover what the authors have to say about the numerous illustrations.

FUSION-WELDING DEVELOPMENTS

Recent research and scientific study have improved welding processes more rapidly than the materials employed. Development of different types of filler metal and modification of base metals to render them more suitable for fusion welding present great opportunities to the metallurgist, in the opinion of C. W. OBERT as expressed in his paper, "Recent Developments in Fusion Welding," and with intelligent guidance of capable scientists fusion welding has a broad and promising future. Mr. Obert is an A.S.M.E. member and is associated with the Union Carbide & Carbon Research Laboratories, New York, N. Y., as consulting engineer. For many years, he has been associated with the work of the A.S.M.E. Boiler Code Committee, first as its Secretary and more recently as Honorary Secretary.

RADIOGRAPHIC INSPECTION OF PIPE JOINTS

While X-ray examination of shop-welded joints is recognized procedure in connection with boiler drums, petroleum stills, and similar constructions, the apparatus was too bulky and the tubes were unsuited to the rough treatment that they were likely to receive in the field. In his article, "Radiographic Inspection," H. R. ISENBURGER describes a technique that has been developed for testing field-welded joints in pressure piping. This not only involves the penetration of both pipe walls but also directs the central beam approximately parallel to the scarf of the weld which enables any defects that are alongside of the scarf to be detected. The author is a member of the American Society for Testing Materials and the American Welding Society and has been president of the St. John X-Ray Service, Inc., Long Island City, N. Y., since 1933.

SURFACE QUALITY

Seldom does a book review turn out to be a major article, but when the book is written in a language few American engineers read easily—if at all—and when it is on a subject that a majority of machine-shop men are keenly interested in, exceptions rule, particularly if competent and indefatigable reviewers are to be found to do the job. Such a review is that by E. J. ABBOTT and EDGAR GOLDSCHMIDT, of the Physicists Research Bureau, Ann Arbor, Mich. So unusual did the review of Gustav Schmaltz's book on surface quality turn out to be, and so extensively did the reviewers cover it by comment and illustrations, that we cabled the German publisher for permission to reproduce the tables and illustrations and secured from him a most gracious response. Here, then, is a brief treatise on the subject matter of an extraordinary book prepared by experts in the subject. Dr. Abbott, it will be recalled, wrote a paper for Mechanical Engineering in 1933 on "Specifying Surface Quality" and will present a paper on the "Profilometer for the Rapid Measurement of Surface Roughness," at the 1937 Annual Meeting of the A.S.M.E. He was for a time connected with the University of Michigan, but in 1935 he took up the work of applying a physicist's knowledge and training to the solution of problems in industry.

STEWART WAY, who is associated with the Westinghouse Research Laboratories, also writes on surface finish, and describes a modification of the Schmaltz straightedge-shadow method of measurement which enables irregularities smaller than 0.00005 in. in height (and that's very small!) to be observed by obtaining a 340× magnification of the image cast by a straightedge on the surface that is being examined. Mr. Way was educated at Stanford and Göttingen and has a doctor's degree from the University of Michigan for graduate study.

SELECTION OF COAL

Coal selection is difficult because numerous factors of equipment and coal characteristics are involved, some of the latter are not capable of definite laboratory measurement as yet, and the relations of some measurable characteristics to performance of the coal are not definitely known. To simplify the problem, R. A. SHERMAN suggests research and education as two avenues of approach in the paper "Status of Our Present Knowledge of Coal Selection for Steam-Generating Equipment." The author, who is a graduate of the State University of

Iowa, is a member of the A.S.M.E., was associated with the U. S. Bureau of Mines as a coal analyst and fuel engineer from 1916 to 1930. For the last seven years, he has been head of the fuels division at the Battelle Memorial Institute, where he has conducted a program of research for Bituminous Coal Research, Inc., and is supervising another on the treatment of coal with oil to allay dust.

SEWAGE-SLUDGE GAS AS FUEL

When W. B. WALRAVEN presented a paper entitled "Adapting Gas Engines to Sewage-Sludge Gas," at a meeting of the A.S.M.E. Oil and Gas Power Division at State College, Pa., last August, he prefaced his comments by confessing that, as a civil engineer, he knew nothing about engines. Hence, he wanted to learn, and proceeded to ask a lot of questions that had the experts guessing and explaining and disagreeing for a couple of hours. Mr. Walraven appeared to be grateful and admitted he had learned something, but others learned something from him. Inasmuch as the good engineer is interested in civic affairs and may be asked to advise with his fellow taxpayers on matters of sewage disposal, it seemed probable that more persons than Diesel-engine experts would find Mr. Walraven's paper interesting and profitable. The experiences reported by Mr. Walraven have to do with sanitary districts in the Middle West. Mr. Walraven has been sanitary engineer of the Springfield (Ill.) Sanitary District since 1924.

EDUCATION AND LEADERSHIP

When the newspapers announced that Dr. KARL T. COMPTON, president of the Massachusetts Institute of Technology, was going to speak at a luncheon in Boston in connection with the New England Distribution Conference, we sent for the address because Dr. Compton always has something worth-while to say. Nor were we disappointed. "Education and Business Leadership" is an important subject in these times when there is so much education to be had and when so much business leadership is sorely needed. Few men know as much as Dr. Compton does about engineering schools, for he is chairman of the Committee on Engineering Schools of the Engineers' Council for Professional Development. Last month this Committee reported the results of its scrutiny for purposes of accrediting under the E.C.P.D. procedure of 617 engineering-school curricula throughout the United States. That ought to guarantee Dr. Compton's knowledge of one portion of his subject. As to the other, the president of an institution which is closely allied with business through its research activities and through the thousands of alumni it has sent out into business and industry may be expected to have more than an academic knowledge of the world outside. Besides, running a great educational institution is a business that calls for a very high degree of leadership. Because many businesses and industries today are based on engineering, the man with a college education, as Dr. Compton points out, is favorably equipped to rise to an administrative position. Those who know Dr. Compton can easily imagine how his blue eyes must have brightened when he compared educational institutions to businesses—all the way from the mail-order house to the pawnshop—and claimed that M.I.T. was a specialty shop.

LIBRARIES AS ENGINEERING TOOLS

Too many engineers regard a library search, says G. M. DEXTER, as a simple job that is beneath their dignity. On the contrary, it is an increasingly important engineering tool in these days of extensive research and rapid technological progress if unnecessary expense in repeating mistakes that other men have made is to be avoided and new designs and inventions are to be developed from where others have stopped. The article, "The Library as an Engineering Tool," mentions various sources of information, such as Government reports, economic data, and general and special indexes with lists of each and gives suggestions regarding their use and special library facilities that are available. Mr. Dexter is engineer in charge of management reports, Bitting, Inc., New York, N. Y. He received the degree of C.E. from the Massachusetts Institute of Technology and M.E. from the Polytechnic Institute of Brooklyn. Mr. Dexter, who is a member of the A.S.M.E., has been associated for various periods with the Honolulu Iron Works Co. at its office in New York, N. Y., and Peabody, Smith & Co. and the Sherman Corporation, both of New York, and the Finn Iffland Company, Scranton, Pa.

It would be easy to get enthusiastic about the value of Mr. Dexter's compilation of sources of engineering information. This "road map" of the engineering literature will appeal particularly to young research workers.

A.S.M.E. ANNUAL MEETING EXCURSION PLANNED TO ROCKEFELLER CENTER

(In the center is the 70-story R.C.A. Building with La Maison Francaise (left) and British Empire Building (right) at its base. At the right may be seen the 41-story international Building with the Palazzo d'Italia at the left and a portion of the International Building East at the right. Behind the International Building is Radio City Music Hall and the 31-story R.K.O. Building. To the left is the 36-story Nine Rockefeller Plaza building and the Center Theater in the background. See page 872 of this issue for excursion plans.)

A.S.M.E. NEWS

And Notes on Other Engineering Activities

A.S.M.E. 1937 Annual Meeting to Draw Large Attendance in New York, Dec. 6 to 10

Full and Varied Program Provides for Every Member's Interests and Entertainment

JUDICIOUSLY mixing technical sessions with social gatherings and opportunities for the discussion of Society affairs, The American Society of Mechanical Engineers will assemble in New York during the first week of December for its fifty eighth Annual Meeting. Headquarters for the meeting will be, as usual, the Engineering Societies Building, where all technical sessions and majority of the social events will be held. The program, which commences on Monday, December 6, and runs through Friday, December 10, includes a wide variety of technical subject matter and social events, and, as usual, will also make provision for sessions of dozens of committees whose members look upon the Annual Meeting as a convenient time to discuss their problems. An outline of the program as it stands to date will be found in these pages, and for the convenience of those who wish to read in advance papers to be presented, the issues of MECHANICAL ENGINEERING and Transactions in which preprinted papers appear have been noted.

Society Affairs to Be Discussed

Consideration of Society affairs is amply provided for in the meetings of the Council on Monday and Friday, the Annual Business Meeting, and the Local Sections Conference, which are regular features of the December convention. Reports of Society committees have been prepared and will be available for discussion, and the report of the Council and the Finance Committee will be presented and subsequently published in January in MECHANICAL ENGINEERING.

Society members are looking forward with keen anticipation to Presidents' Night, the Annual Dinner to New Members, and to Honors Night, at which time the Society prizes will be awarded. Towne and Thurston lecturers have been announced and the subjects of the addresses promise both entertainment and instruction. Countless gatherings and informal meetings of groups and individuals, from casual and unexpected conversations in the lobby and Engineers' Club to College Reunions, will provide that opportunity for the renewal of acquaintanceship and the making of new friendships that are such important features of large national gatherings.

Plastics Symposium Arranged

In spite of earnest attempts on the part of those in charge to reduce the number of simultaneous sessions and the volume of papers for discussion, the technical program is once more packed with contributions, the hearing of which could not well be denied engineers traveling from all parts of the nation to take part in discussions of the trends and developments vital to their interests. Among the familiar topics that have featured A.S.M.E. programs for more than 50 years and that are in such an active state of development that discussion of them still draws large audiences are newer subjects that testify to the ever-broadening field with which the mechanical engineer is required to deal. Important and significant in this connection are two sessions sponsored by the Machine Shop Practice Division devoted to the subject of plastics. Four papers are to be presented at these two sessions, and they will deal with four phases of the subject. Types, properties, and new developments in plastics themselves will constitute the subject of one paper. Another will deal with developments in machinery used for plastic molding. From the point of view of design the other two papers will consider mechanical design of plastic parts and art in plastic design. Recent rapid progress in the extensive use of plastic materials has brought about the demand for consideration of the subject by the Society, and careful planning and selection of speakers promise that those who attend will be well repaid.

Professional Divisions Participate

L. C. Morrow, of the Management Division, has secured the consent of Joseph W. Madden, Chairman of the National Labor Relations Board, to talk on the principal decisions of the Board. So universal in interest in this controversial subject that a large audience and probably an animated discussion can be guaranteed.

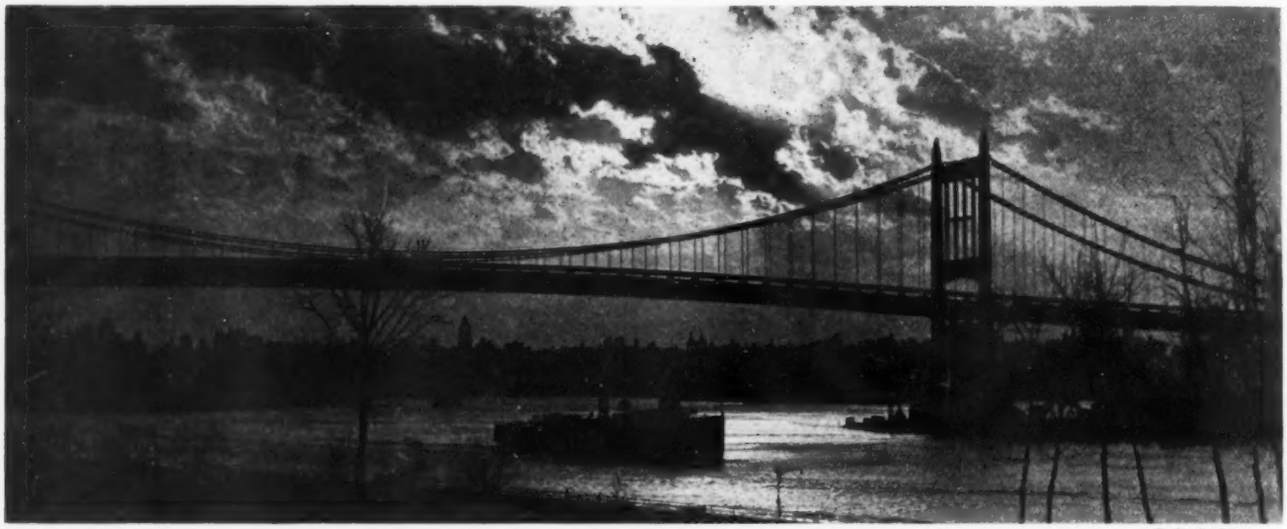
In the power field high-temperature and high-pressure materials and plants will be considered in several papers. Condensers, pipe bends, heat transfer, panel discussions of specific problems in high-pressure, high-temperature power plants, chemically treated coal, water-cooled stokers, and industrial plants are given their places on the program.

The Applied Mechanics Division offers a rich variety of papers on elasticity, strength of materials, and vibration, and the Hydraulic Division resumes its discussion of water hammer with two crowded sessions covering the developments of the past few years reported by experts from all over the world. Lubrication, materials handling, safety, motion study, apprentice training, aeronautics, springs, maintenance, process industries, textile printing and drying, to mention a few subjects in general terms, will be covered by dozens of papers contributed by the divisions involved. The Aeronautic, Railroad, and Oil and Gas Power divisions are well represented on the program by papers that will attract the attention of engineers, whatever their principal interests may be. In addition to the symposium on plasters the Machine Shop Practice Division offers papers on surface quality, carbide-tipped drills, safety, and lubrication, and the important subject of safety in machine design will be adequately covered.

Inspection Trips a Feature

In addition to the wealth of technical material to be covered by the technical sessions, plant visits and inspection trips are being arranged for visitors from out of the city, and for those so closely confined to their individual tasks in New York that they have not had an opportunity to study the activities of their fellow engineers in the Metropolitan area. Further announcement of these opportunities for plant visits has been released by the committee in charge and is noted in greater detail on page 872.

From whatever point of view the 1937 Annual Meeting is viewed, it will be generally acknowledged that attendance for part of the week at least is an obligation which every alert member owes to himself. With the Society's financial status on a much more favorable basis, attention to problems of developing the technology of the immediate future will be given strongest emphasis, with the expectation that every one in attendance will carry back to his day-by-day job a strong stimulus to greater productive effort. With improvement in the general business conditions over that of recent years, the total number of members to register and take active part in discussions and attendance should break all previous records. It is a meeting that no one will wish to miss.



C. P. Cushing

TRIBOROUGH BRIDGE TO WHICH AN ANNUAL MEETING EXCURSION IS PLANNED

Tentative Program for 1937 Annual Meeting

MONDAY, DECEMBER 6

9:00 a.m.

Council Meeting
Section Group Delegates' Conference
Conference Sugar Group (Process Industries Division)

4:00 p.m.

Business Meeting

6:00 p.m.

Motion-Study Dinner

8:00 p.m.

Motion-Study

Labor's Attitude Toward Time and Motion Study

Speakers: Glenn L. Gardner and Geo. S. Dierstein

Machine-Shop Practice

Profilometer for the Rapid Measurement of Surface Roughness, by E. J. Abbott
Maintenance of Cemented Carbide-Tipped Drills, by Malcolm Judkins

TUESDAY, DECEMBER 7

9:30 a.m.

Elasticity

Stress Model of a Complete Airship Structure, by L. H. Donnell, E. L. Shaw, and W. C. Potthoff
Distortion of the Photoelastic Fringe Pattern in an Optically Unbalanced Polariscope, by R. D. Mindlin
The Correlation of Creep and Relaxation Properties of Copper, by C. C. Davenport
The Properties of Photoelastic Materials, by C. W. Armstrong and G. H. Lee
Buckling of Elastic Plates of Variable Thickness, by R. Gran Olsson and M. E. Reissner
Rectangular Plate Problems, by Gerald Pickett

Plastics—I

Plastics Materials, by Harry Burrell
Development in Molding Equipment, by L. F. Rahm

Sanitation Symposium

Symposium on the Adaptation and Development of Mechanical Equipment for Sanitary-Engineering Purposes
Industrial Experience as Applied to Sanitation, by Nells B. Lund
Mechanical Engineering for Sanitation, by Lewis V. Carpenter
Mechanical Background of Refuse Incineration, by Henry W. Taylor

Drying

Hemp and Flax From the Seed to the Loom, G. A. Lowry
Spray Drying, by William Spencer Bowen

Mechanical Springs

Heavy Helical Springs, by C. T. Edgerton
Wire Springs, by F. P. Zimmerli
Spring Materials, by D. J. McAdam, Jr.

12:30 p.m.

Maintenance

Maintenance Lunch (Management Division)
Maintenance, Management, and Control, by William O. Lawson, A. E. Windle, and John I. Thompson

2:00 p.m.

Management

Decisions of the National Labor Relations Board, by J. Warren Madden

Plastics—II

Mechanical Design of Plastic Parts, by David M. Buchanan
Of Art in Plastics Design, by R. J. Hill

General Process

Mechanical Processing of Vegetable Oils, by W. Wade Moss, Jr.
Rupture Disks for Safety in Process Equipment, by C. E. Huff
Training Engineers for the Process Industry, by A. H. Cooper

Critical-Pressure Steam Boilers

Progress Report of an Investigation of the Oxidation of Metals by High-Temperature Steam, by A. A. Potter, H. L. Solberg, and G. A. Hawkins
Protecting Steel From Intercrystalline Cracking in Aqueous Solutions, by W. C. Schroeder, A. A. Berk, and R. A. O'Brien
Decomposition of Sodium Sulphite Solutions at Elevated Temperatures, by F. G. Straub
Some Results From the Research on Flow Nozzles, by Howard S. Bean and Samuel R. Beitler (To be read by title)

High-Temperature Joints

Welded Joints, by F. L. Everett and Arthur McCutchan
High-Temperature Joints, by Joseph Marin
Bolted Joints for High-Pressure Vessels, by E. O. Waters
Practical Aspects of Turbine Joints, by C. B. Campbell
Effect of Temperature Variation on the Creep Strength of Steels, by E. L. Robinson

8:00 p.m.

Honors Night

WEDNESDAY, DECEMBER 8

9:30 a.m.

Management

Scientific Management in the Unionized Plant, by Harold D. Bergen and George W. Taylor

Power

Prevention of Slime in Steam Condensers, by R. B. Martin

Further Studies of Three-Dimensional Pipe Bends, by William Hovgaard

Heat Transfer

Experimental Investigation of the Influence of Tube Arrangement on Convection Heat Transfer and Flow Resistance in Cross Flow of Gases Over Tube Banks, by Orville L. Pierson

Experimental Investigation of Effects of Equipment Size on Convection Heat Transfer and Flow Resistance in Cross Flow of Gases Over Tubes Banks, by E. C. Huge

Correlation and Utilization of New Data on Flow Resistance and Heat Transfer for Cross Flow of Gases Over Tube Banks, by E. D. Grimison

Heat Transfer to Boiling Liquids, by W. H. McAdams and George A. Atkin

Textile-Printing Symposium

Mechanical Equipment on Printing, by Wallace Taylor

Wanted—More Engineering in Textile Printing, by J. F. Halloran

Outline of Dyestuffs and Gums Used in Textile Printing, by I. F. Chambers

Description of Merchandising Requirements, by Stephen J. Kennedy

Strength of Materials

Fatigue Failure From Stress Cycles of Varying Amplitude, by B. F. Langer

Simultaneous Effects of Corrosion and Abrupt Changes in Section on the Fatigue Strength of Steel, by T. J. Dolan

Fatigue Life of Tapered Roller Bearings, by W. O. Clinedinst

12:30 p.m.

Student Luncheon Hydraulic Luncheon
Textile Luncheon

2:00 p.m.

Power Panel Discussion

New High-Pressure, High-Temperature Power Stations.

Discussion will cover:

The solution of unusual construction problems; capacity and efficiency performance data; troubles with equipment; starting-up procedure

To be discussed by: J. F. Muir, D. S. Brown, A. E. Grunert, C. H. Spiehler, E. H. Krieg, Louis Elliott, G. T. Shoemaker, J. A. Reich, J. N. Landis, and W. E. Caldwell.

Supplemental general discussion from the floor.

Management

Scientific Management in the Unionized Plant—A Case History

Process-Control Symposium

Control of Processes Involving Heat Transfer, by Edmund D. Haigler

Control of Continuous Processes, by E. S. Bristol and J. C. Peters

Control Applications in the Oil-Refining Industry, by Donald J. Bergman

Vibration

An Improved Method for Calculating Free Vibrations in Systems of Several Degrees of Freedom, by W. M. Dudley

Steady Oscillations of Systems With Non-Linear and Unsymmetrical Elasticity, by M. Rauscher

Vibration Stress Measurements in Strong Centrifugal Fields, by C. M. Kearns and R. M. Guerke

Modern Aids to Vibration Study, by E. H. Hull

Heat Dissipation Through an Annular Disk or Fin of Uniform Thickness, by W. M. Murray

General Theory

Second Water-Hammer Symposium

Report of the Committee on Water Hammer, A.S.M.E., by S. Logan Kerr, Chairman

Air Chambers in Discharge Pipes, by Lorenzo Allievi (Translated by Eugene E. Halmos)

Theory of Resonance in a Pressure Conduit, by Charles Jaeger

Hydraulic Phenomena in Fuel-Injection Systems for Diesel Engines, by Kalman J. DeJuhasz

Experiments and Calculations on the Resurge Phase of Water Hammer, by J. N. LeConte

6:30 p.m.

Annual Dinner, Hotel Astor

THURSDAY, DECEMBER 9

9:30 a.m.

Water Hammer in Hydroelectric Plants

Report of Subcommittee on Penstock Failures, by R. W. Angus, Chairman

Relation of Relief Valve and Turbine Characteristics in the Determination of Water Hammer, by Earl B. Strowger

Operation of Emergency Shut-Off Valves in Pipes Lines, by F. Knapp

Application of Heaviside's Operational Calculus to the Solution of Problems in Water Hammer, by F. M. Wood

Fuels

Water-Cooled Underfeed Stokers, by Joseph S. Bennett

Industrial Power Plants, by C. D. Boomhower

Lubrication

Thrust Bearings, by F. C. Linn and R. Sheppard

Tests of a 7 × 9-In. Bearing at 3600 Rpm, by L. M. Tichvinsky

Steel-Plant Lubrication, by J. F. Pelly

Management-Materials Handling

Importance of Materials Handling as a Conserver of Skilled Labor, by C. Keith Piveat

Safety

The Application of Safety in Mechanical Production, by Everett W. Martin

The Relation of an Adequate Job-Training Program to Accident Prevention, by Glenn L. Gardiner

12:30 p.m.

Luncheon. Hydraulic Division with A.S.C.E. Power Division and American Water Works Association

2:00 p.m.

Water Hammer in Water-Works Systems

Second Water-Hammer Symposium

Complete Characteristics of Centrifugal Pumps and Their Use in the Prediction of Transient Behavior, by R. T. Knapp

Comparison Between Calculated and Test Results on Water Hammer in Pumping Plants, by O. Schnyder

Graphical Study of Water Hammer in Pump-Discharge Lines, by R. W. Angus

Water-Hammer Tests on Transite Pipe, by L. H. Kessler

Water-Hammer Problems in Pumping Plants of the Los Angeles Aqueduct, by R. M. Peabody

Tests on Water Hammer in Pump-Discharge Lines, by E. Bruce Ball

Apprenticeship Training

Apprentice Training, by Wm. F. Patterson

Fuels

Panel Discussion on Chemically Treated and Dedusted Coal; Deslagging of Boiler Surfaces

Lubrication

A Method of Observation and Measurement of Surface Finish, by S. Way

Running-In Characteristics of Some White-Metal Journal Bearings, by S. A. and T. R. McKee

Static Friction, by W. E. Campbell

Machine-Shop Practice

What Constitutes a Safe Dust Level in Foundries, by Theodore F. Hatch

Safety in Machine Design, by A. W. Luce

Radiographic Inspection, by H. R. Isenburger

8:00 p.m.

Aeronautics

Design and Construction of Airplane Fuel Tanks, by F. V. Hartman

Use of Inert Gases in Reducing Hazards in Aviation, by J. A. Abels

General Progress Report on Aviation

Oil and Gas Power

Some Data on Diesel-Electric Switching Locomotives, by J. W. Anderson

The Effects of Changes of Speed and Load on the Mechanical Friction Losses of Reciprocating Engines, With Special Reference to the Four-Cycle Trunk-Piston Type, by F. H. Dutcher

Railroad

Stresses in Railway Axles and Locomotive Crankpins, by R. Eksergian

Air Conditioning of Railroad Passenger Cars, by L. W. Wallace and G. G. Early, Jr.

Report of Progress in Railway-Mechanical Engineering by Survey Committee RR6, by A. Giesl-Gieslingen

Annual-Meeting Excursions Offer Wide Choice of Worth-While Trips

To Rockefeller Center, the "Normandie," Yacht-Testing Tank at Stevens, and R. H. Macy Power Plant

PLANT visits, long an interesting feature of A.S.M.E. Annual Meetings, are included in the program of the 1937 meeting The tentative schedule includes seven excursions that have been definitely planned to various points of engineering interest, with probably three additional visits to manufacturing and process plants in the vicinity of New York City. Information on the trips scheduled at the time of going to press is contained in the following paragraphs.

Rockefeller Center

On Monday morning, Dec. 6, the trip through the mechanical quarters of Rockefeller Center which has proved so interesting at previous meetings will be repeated. A charge of 70 cents per person will be made in connection with this excursion.

The "Normandie"

Two excursions with a marine flavor are scheduled for Tuesday, Dec. 7. In the morning the general passenger and living accommodations on the *Normandie* of the French Line will be inspected, and the engine room will be visited unless some unexpected repairs prevent. While both men and women will be welcome to visit the passenger quarters, the engine-room inspection is limited to men only.

Yacht-Testing Tank at Stevens

The afternoon excursion will be a repetition of last year's inspection of the yacht-testing tanks at Stevens Institute of Technology, Hoboken, N. J. The tanks, which were used in designing this year's cup defender and many other racing yachts, will be in operation.

Waterside Station—Triborough Bridge

On Wednesday, Dec. 8, three excursions are scheduled. The morning trip will be to the Waterside Station of the Consolidated Edison Company of New York, Inc., where the largest superposed turbine in operation has been installed and a second unit is under construction. A feature of this station is the new stack which discharges the products of combustion at a height of 225 ft above the sidewalk or above any building within a $\frac{1}{4}$-mile radius. One excursion in the afternoon will be made by chartered motorbusses over the Triborough Bridge and through the site of the 1939 World's Fair.

On the return trip, a stop will be made at Ward's Island to inspect the large sewage-disposal plant that is now in partial operation and ultimately will handle all sewage and surface water from the northern portion of the Borough of Manhattan and the Borough of the Bronx. The power required to handle the water and sludge is 22,000 hp, and sludging will be accelerated by forced aeration.

R. H. Macy & Co. Power Plant

The other afternoon trip is to the power plant of R. H. Macy & Co., Inc., which is the largest private plant in New York City and is also interesting because of the great diversity of equipment installed. This includes steam and Diesel engines and condensing and exhaust turbines, two of the last driving refrigerating machines for air conditioning.

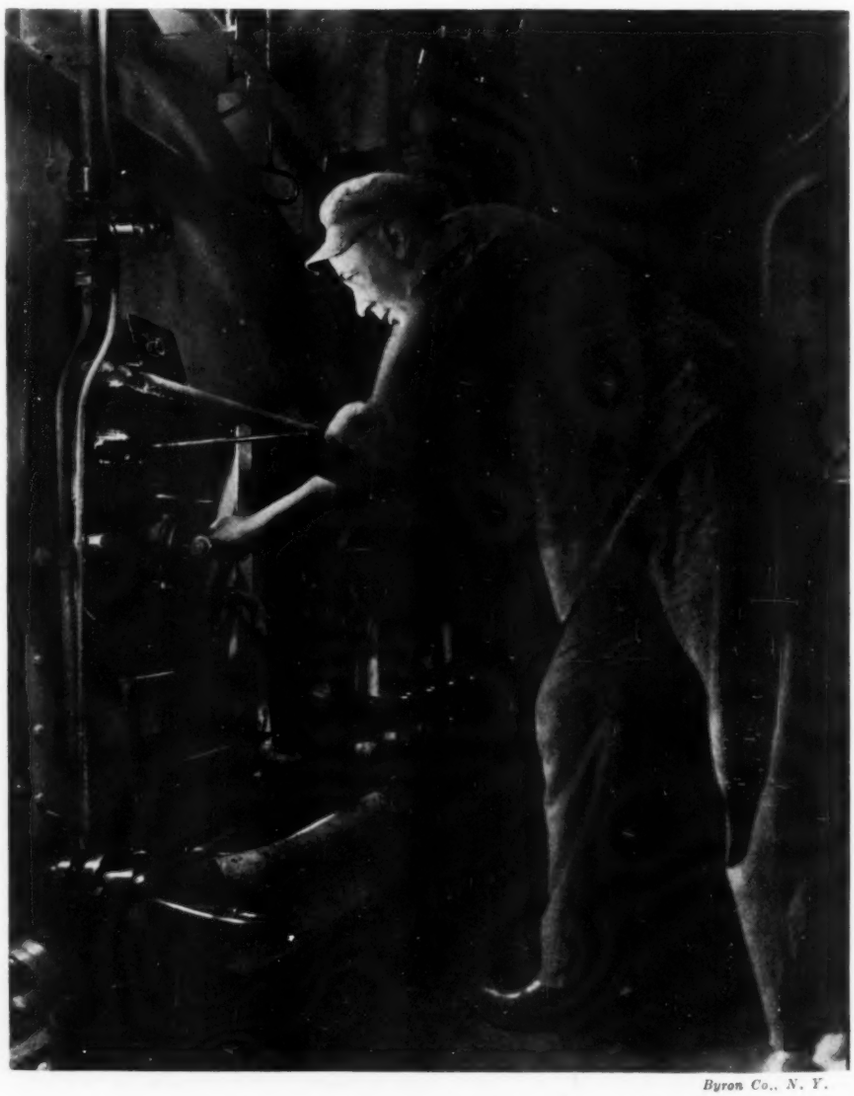
Only one excursion is scheduled for Thursday, Dec. 9, and this will be in the afternoon. At that time, the building at the New York portal of the Lincoln Tunnel under the Hudson River will be visited and the ventilating equipment that it contains will be inspected.

A.S.M.E. Officers Elected for Coming Year

TELLERS of Election, W. G. Hauswirth, W. F. Carhart, and E. J. Flavin have submitted their report of the ballot vote for directors of The American Society of Mechanical Engineers for 1938, as follows:

Office	Nominee	Votes
President	Harvey N. Davis.....	3157
Vice-Presidents	Frank O. Hoagland.....	3164
	Bennett M. Brigman....	3157
	Harte Cooke.....	3164
	Warren H. McBryde.....	3165
	Lawrence W. Wallace...	3158
Managers	Carl L. Bausch.....	3165
	Samuel B. Earle.....	3162
	Frank H. Prouty.....	3165

The total number of ballots cast was 3465, with 3169 valid and 296 defective. Biographical sketches of the nominees for office may be found on pages 555–559 of the July issue.



Byron Co., N. Y.

LIGHTING UP AN OIL-BURNING BOILER ON THE *Normandie*
(An excursion to the *Normandie* is planned during the A.S.M.E. Annual Meeting.)

Registration Fee for Non-Members at the 1937 Annual Meeting

There will be a registration fee of $2 for nonmembers attending the 1937 A.S.M.E. Annual Meeting. This is in accordance with the new ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests may avoid this fee by writing to the Secretary of the Society before November 20 asking for a guest-attendance card for the Annual Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to two per member.

A.S.M.E. Awards Announced

To Be Presented at Annual Meeting

THE BOARD of Honors and Awards and its Committee on Medals have announced the following list of honors to be conferred at the 1937 Annual Meeting of the Society:

The Holley Medal to Frederick G. Cottrell of Research Associates, Inc., Washington, D. C.

The A.S.M.E. Medal to Edward P. Bullard of the Bullard Company, Bridgeport, Conn.

The Worcester Reed Warner Medal to Clarence F. Hirshfeld of the Detroit Edison Co., Detroit, Michigan.

The Melville Medal to Alfred J. Buchi of the Buchi Syndicate, Winterthur, Switzerland.

The Junior Award to Leslie J. Hooper of Worcester Polytechnic Institute, Worcester, Mass.

The Charles T. Main Award to Allan P. Stern of The Case School of Applied Science.

The Undergraduate Student Award to Gino J. Marinelli of Rensselaer Polytechnic Institute.

Members of the Board of Honors and Awards are R. C. H. Heck, Chairman, L. P. Alford, Harte Cooke, Willis H. Carrier, and Joseph W. Roe.

The Committee on Medals, functioning under this Board, has as its personnel the five members of the Board of Honors and Awards and A. M. Greene, Jr., James W. Parker, Roy V. Wright, John Lyle Harrington, Dugald C. Jackson, Robert Sibley, Carl L. Bausch, Robert L. Sackett, Frank M. Gunby, Edwards R. Fish, Henry C. Meyer, Jr., L. W. Wallace, Harold A. Everett, Geo. A. Orrok, and H. A. S. Howarth.

First A.S.M.E. National Fall Meeting Proves New Convention Policy Sound

Erie Section Host to Members From Entire Nation

BETWEEN three hundred and fifty and four hundred members and guests of The American Society of Mechanical Engineers took part in the highly successful 1937 National Fall Meeting of the Society at Erie, Pa., Oct. 4 to 6, with the Lawrence Hotel as headquarters. This was the first of a new program of Society meetings on a national scale in which four such gatherings are contemplated annually. Throughout the current fiscal year the National Fall Meeting at Erie will be followed by the Annual Meeting, New York, December 6 to 10, the National Spring Meeting in Los Angeles, Calif., March 23 to 25, 1938, and the Semi-Annual Meeting at St. Louis, Mo., June 20 to 24, 1938.

That members of the Society have responded to the new plan with gratifying approval was noted in the fact that persons registered at Erie came from the Southeast, the Southwest, and the Pacific Coast and in the high quality of papers presented and discussed. With the holding a greater number of national meetings in localities easy of access to the Society's membership, opportunities for profitable engineering conventions are more widely and frequently distributed and the congestion of simultaneous sessions, necessary to accommodate the increasing number of papers presented for discussion, is eased at Annual and Semi-Annual Meetings.

At Erie throughout the entire meeting were President James H. Herron and Mrs. Herron, and President-Elect and Mrs. Harvey N. Davis. A meeting of the Executive Committee of the A.S.M.E. Council brought council members W. A. Shoudy, K. H. Condit, and J. W. Parker, as well as W. T. Conlon, representing the Finance Committee, and D. B. Prentice, and A. J. Kerr, Local Sections. C. E. Davies, secretary of the Society, was prevented from attending because of a cold from which he was convalescing. Important actions of the Executive Committee are noted elsewhere in this section.

Arrangements at Erie Well-Planned

Wide diversity of industrial activity in the Erie district provided opportunity for instructive plant visits which were well-organized and hugely appreciated. Program arrangements left afternoons free for these organized visits so that no conflicts with technical sessions occurred. Convenient transportation facilities and abundant guide service, supplemented by numerous individual courtesies, added greatly to the enjoyment of these trips and merit especial commendation for all local groups and individuals concerned in them.

An advance registration of a hundred out-of-town members and guests assured the Erie committee, which B. S. Cain served as general chairman, of an auspicious start. By the time the first sessions were convened on Monday morning, nearly two hundred had been welcomed by James Burke, chairman of the Reception Committee, and his aids, and J. F. Wadsworth, chairman of the Hotel Committee, who were in constant attendance. In charge of information and registration was a committee headed by W. L. Hunter. G. W. Bach served as chairman of the committees on Technical Events and Publicity, and those on Finance, Entertainment, Plant Visits, and Printing and Signs were headed by Charles Oergel, John St. Lawrence, A. J. Woodward, and G. H. Kaemmerling, respectively. Mrs. B. S. Cain and her committee seemed thoroughly to enjoy their duties, performed with cordiality and warm hospitality, of welcoming and entertaining the women.

A luncheon on Monday noon and a dinner Tuesday evening served to bring all members and guests together for informal sociability and the opportunity of listening to President Herron and other prominent speakers.

Meetings of administrative and other Society committees, always a feature of national gathering, brought together at Erie the Local Sections Committee and the executive committee of the Machine Shop Practice Division, as well as the Executive Committee of the Council.

Technical Papers Cover Many Subjects

To one observer at least the formal sessions of the 1937 National Fall Meeting were divided into three general categories. By far the greatest number of sessions were those sponsored by the divisions at which technical papers were read and discussed. Sponsoring these sessions were the Power, Railroad, Machine Shop Practice, Oil and Gas Power, Hydraulic, Fuels, Process, and Petroleum divisions, and to these must be added those held by the Committee on the Cutting of Metals and that on Instruments. In the second category should be placed the two significant sessions of the Management Division whose papers and discussions were devoted to subjects of broad and fundamental nature made particularly acute as to interest because of the present-day importance of industrial problems resulting from labor conditions. To the third category belongs the stimulating paper presented before a large and attentive audience on Monday evening dealing with the young mechanical engineer in the electrical-manufacturing industry.

Inasmuch as most of the papers presented at the technical sessions of the first category have been or will be published by the Society, and because space limitations prevent any adequate summary of them and the discussion they evoked, no attempt at such a summary will be made. At the Power Session a new low-alloy pearlitic steel for high-temperature service and the rehabilitation of Station No. 3 of the Rochester Gas & Electric Corp. were discussed. The railroad division, on Monday, listened to papers on the flexible mounting of

Diesel engines for transportation service, to an excellent summary of the place of railroads in modern transportation, and to an exposition of the place of research and development as applied to the mechanical department.

Welding as a machine-shop technique was discussed at the well-attended Monday morning session of the Machine Shop Practice Division from the points of view of the engineering designer and the shop operator. A paper on a simple form of hydraulic dynamometer drew the Hydraulics and Oil and Gas Power Divisions together for a joint session.

Members of the Fuels Division met to discuss a paper on the combustion of pulverized coal in industrial furnace chambers and the burning of waste liquors in the kraft- and soda-paper industries.

On Tuesday morning the Process Industries Division directed its attention to the distribution and use of steam, power, and water in the manufacture of sulphite paper and to residence and small office air-conditioning.

Under the joint auspices of the Railroad and Machine Shop Practice divisions the electric gage was described and its use was noted in a paper dealing with experience with the dynamic effect of locomotives and cars on railroad tracks.

Within a stone's throw of the first development of the petroleum industry it was natural to expect the Petroleum Division to consider some of its problems, which was done in discussions of papers on repressuring and pumping oil in the Pleasantville-Titusville area and on the geological phases of repressuring.

Two papers on the general subject of metal cutting, one concerned with the determination of tool-life cutting-speed relationship by facing cuts and the other with power and forces in milling S.A.E. 3150 steel with helical mills, were heard on Wednesday morning at a joint session of the Special Research Committee on Cutting of Metals and the Machine-Shop Practice Division.

Under the auspices of the Committee on Industrial Instruments and Regulators of the Process Industries Division four papers comprising a symposium on instruments were presented on Wednesday morning.

Production Planning Interests Large Group

Into the second category of technical sessions fell five papers presented at two sessions of the Management Division. Four of these related to the problems of production planning and control and the fifth present-day trends in wage incentives. At both sessions an attentive audience was ready with questions and discussion that proved the intense interest and popularity of the subjects presented. Events in labor relations which have marked the recovery period have placed emphasis on the social as well as the economic aspects of these important matters and from the eager interest displayed it was evident that the challenge to management is being intelligently met during the present period of strained and exceptional conditions.

At the first session two concrete examples of production planning and control were presented by men responsible for administering them. These were followed by a discussion of principles involved in this branch of industrial management.

W. A. Barr, who is vice-president and factory manager of Foote Bros. Gear & Machine Corp., Chicago, Ill., described a system designed for a plant in which most of the orders are received by what is in general a large job shop engaged in nonrecurrent business. The fundamentals of the system described by Mr. Barr are set forth in the May, 1937, issue of *Factory*. Mr. Barr's exposition covered the plan of procedure with each shop order; the method of controlling performance by means of current information available almost continuously by direct communication between shop and a central clerical office, with daily production-control meetings of shop executives; and the organization necessary to operate the system.

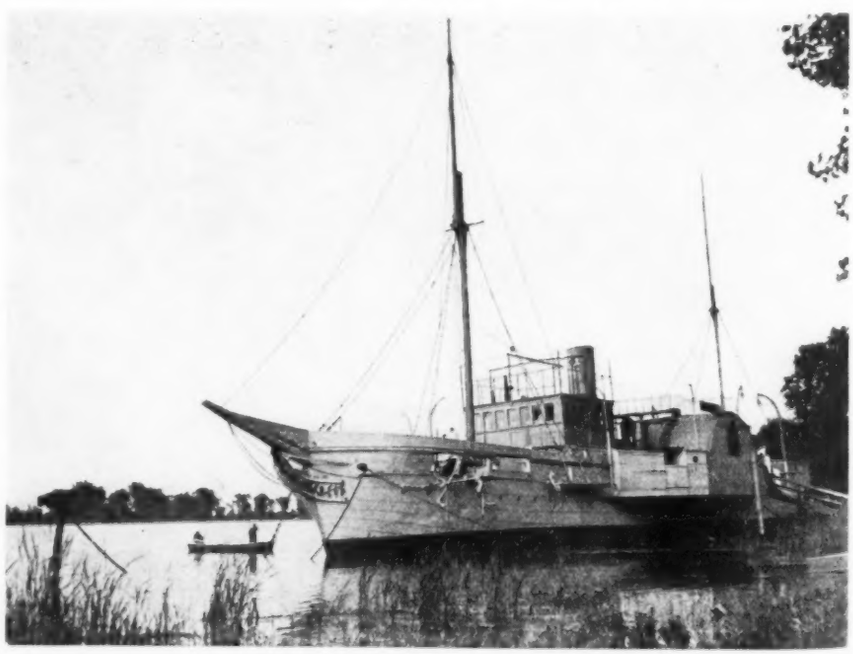
E. L. Sheehy, planning engineer, Motor Products Corporation, Detroit, Mich., described another system used in a plant manufacturing parts for automobiles in large numbers, in which an attempt is made to reduce the expense of the control system and to simplify it to avoid confusion.

R. H. Rositzke, of R. H. Rositzke & Associates, New York, N. Y., presented a discussion of the principles of production control in a manufacturing department in which he explained its general scope and responsibilities, the duties of the planning manager, and the specific duties of the planning division.

Reverting to specific cases but considering a company with many plants of various types, T. M. Landy, of the Manufacturing General Department, General Electric Company, Schenectady, N. Y., spoke on Wednesday morning on production planning and control, and described recent developments made in this field by his company. In the system described he showed that by increasing the time spent in planning, the total time of planning, production, and accounting had been reduced.

Trends in Wage Incentives

Following Mr. Landy, Merritt Lum, industrial-relations department, Johns-Manville Corporation, New York, N. Y., spoke on present trends in wage incentives, directing emphasis to five major points. As a result of expressions from industrialists Mr. Lum offered the opinion that there is a growing opposition to wage-incentive plans on the part of organized labor because such plans are likely to be misunderstood by workers when questions of increasing wages are discussed by labor leaders. While organized labor as a whole is not opposed to plans that increase total production and insure a gain to workers of a fair share of the rewards of increased production, he said, at the present time the "bargaining" view is ascendant over the long-range view. This led to the conclusion that wage plans need simplification so that every worker can figure for himself at the end of every day what he has earned that day. Management, Mr. Lum said, would not "lie down" on the job of trying to evolve such systems and educate workers to understand and accept them. Patience to an astounding degree is needed on the part of management, he continued, in obtaining the desired results, and in



THE *Wolverine* FORMERLY THE *U. S. Michigan*, THE FIRST IRON SHIP EVER BUILT

(Congress appropriated $100,000 on Sept. 9, 1841, for its construction. It was built in Pittsburgh, dismantled and transported to Cleveland by oxcarts, thence to Erie by lake and finally assembled and completed there and launched on Nov. 9, 1843. It was commissioned August 15, 1844, and has 65 years of continuous service to its record as a vessel of the U. S. Navy. Part of this time it was used as a training ship. In 1927 the Government turned the ship over to the city of Erie in charge of the Marine Corps League to be used as headquarters.)

eliminating fear of management and its objectives. Evidence of a growing use of incentives in wage-payment plans was also offered by Mr. Lum. He cited with apprehension statistics of the National Industrial Conference Board to the effect that from 1933 to 1937 hourly earnings had increased 31.8 per cent and average production per man-hour only 4.9 per cent. The way out, he suggested, might lie in the increased use of the measured-day-work plan or some equivalent. In line with this suggestion he cited statistics that showed a growing appreciation of the measured-day-work plan and mentioned as advantages the facts that performance can be judged over fairly long periods, that the plan is understandable, and that it is relatively stable for a given period.

In concluding his paper Mr. Lum said that it was imperative that management be thoroughly sold on whole-hearted cooperation for increased production, and that present-day union philosophy is that of a mass movement in which the individual worker is submerged and lost sight of in consideration for the mass of workers.

In the discussion that followed it was brought out that any wage-payment plan must be clearly understood by the worker, must be fair to the worker, and must be carried out with the cooperation of management and labor.

While none of the five papers presented by the Management Division was available for publication before the meeting, assurances were received that manuscripts would be submitted for publication at a later date.

Education Session Draws Large Crowd

Readers of MECHANICAL ENGINEERING have had the opportunity of reading in the October issue, the paper presented at the general session on Monday evening which constituted the third category of subject matter considered at Erie. This paper, entitled "The Young Mechanical Engineer in the Electrical Industry," was prepared by A. R. Stevenson, Jr., and E. E. Parker, of the General Electric Company, Schenectady, N. Y., and is evidence of the magnitude and variety of the mechanical-engineering work done in a representative electrical-manufacturing plant. As was brought out in the presentation of the paper and in the discussion, 90 per cent of the work in such a company is mechanical engineering from design through production and assembly, and counselors of young men, as well as the men themselves, should recognize this fact in considering career opportunities. In presenting the paper, Mr. Stevenson used the illustrations included in the published paper and several more. Discussion was led by A. M. Dudley, of the Westinghouse Electric and Manufacturing Company, whose long experience in the selection of young men for his employers has abundantly qualified him as an authority.

H. P. Hammond, Dean of the School of Engineering, Pennsylvania State College, who had been invited to act as chairman of the session, drew from the audience much discussion, to which he himself contributed. Frequent mention of the Engineers' Council for Professional Development and to programs of post-collegiate education carried out by groups of junior engineers in several engineering centers placed deserved emphasis on this important phase of engineering internship. Evidence was educed by the discussion to the effect that the educational background of young men entering industry as engineers is both broadening and becoming of a more highly technical order, requiring greater attention to nontechnical, as well as to fundamental scientific and mathematical, subjects which must be given by the junior during his years of cadetship. Possibilities of approach to engineering careers through production departments and drafting rooms, as well as test courses, were brought out, and the desirability of further developing methods of making these approaches more valuable and alluring was admitted. One came away with the impression that in some of the larger industrial organizations today genuine efforts are being expended toward professional development of young men, and with the hope that means can be found, perhaps through activities of local engineering groups, to provide similar opportunities for men engaged with smaller concerns. Side lights of the discussion showed the value of such meeting and publication activities as are being carried on by the A.S.M.E. Division of Applied Mechanics, and the need for discussions covering other major industrial fields directed toward the same objective of exploring the opportunities in them for mechanical-engineering graduates.

General Luncheon Brightens Monday's Program

B. S. Cain, chairman, A.S.M.E. Erie Section, presided at the luncheon on Monday. James H. Herron, president, A.S.M.E., and H. LeR. Emmet, works manager of the General Electric Company, Erie, Pa., member, A.S.M.E., spoke informally. Mr. Herron called attention to the fact that because of its splendid industrial background, Erie was an appropriate place at which to hold the first National Fall Meeting of the Society. He recalled many well-known names of Erie's industrial plants in reminding his audience of the rich industrial history of the city, and referred to some of his own connections with the city and its industries.

Continuing the theme set by Mr. Herron, Mr. Emmet spoke of Erie as a modern industrial city in which the diversity of industry was as great as in any section of the country. He recalled the circumstances that caused the General Electric Company to build its Erie plant 25 years ago and reviewed briefly the extent and variety of the manufacturing work carried on there.

W. L. R. Emmet and A. R. Smith Speak at Dinner Meeting

On Tuesday evening members and guests assembled for a dinner meeting in the ballroom of the Lawrence Hotel. Presiding at the dinner was B. S. Cain, and with him at the speakers' table were the honored guests, the Mayor of Erie, the president and president-elect, members of the Council, and chairmen of the local committees.

After the dinner Mr. Cain introduced Charles Barber, Mayor of Erie, who welcomed members of the Society and their guests in the name of the city. The function of presiding was then turned over to President Herron who introduced the first speaker, A. R. Smith, member, A.S.M.E., engineer in the Construction Engineering Department and managing engineer, Turbine Department, of the General Electric Company, who presented a prepared address entitled "Wealth and Engineering." Mr. Smith's thought-provoking paper, which was received with genuine appreciation and which will be published in a later issue, showed that one of the greatest sources of wealth today is the ability which we possess of doing more and more, not by drawing upon stored products, as in the past, but by gaining knowledge and experience to build new things and to produce the established requirements with greater facility.

"And so," he concluded, "so long as we have such facilities, desires, and ability there should be no occasion for extensive unemployment except for the faulty functioning of this complex civilization which is not so thoroughly understood in all its branches.

"We can afford to discard inefficient and useless things and reconstruct with the modern, and, by so doing, carry on our backs fewer of the barnacles of tradition and leave ourselves free to attack our problem and enjoy our pleasures with a freedom and agility possessed by no other nation.

"And who has done so much in providing a clearing house, free from prejudice and commercialism, for the exchange of such technical information which promotes this condition? Who has encouraged this development which is the most enduring and satisfying part of our national wealth? Who is going to continue to foster this meritorious work in the future?—The American Society of Mechanical Engineers and associated engineering societies."

Following Mr. Smith's address, President Herron presented to the audience Harvey N. Davis, president-elect of the Society, who was warmly applauded, and introduced W. L. R. Emmet, member, A.S.M.E., and its 1929 medalist, consulting engineer, General Electric Company, who spoke on the present status of the Emmet mercury-vapor process of power generation, and particularly of his hopes to extend its application to the field of marine propulsion. Dr. Emmet's address, which was greeted with sustained applause, is to be found on page 840 of this issue.

Plant Visits Show Industry at Its Best

While mention has already been made of the plant visits arranged for those in attendance at the 1937 National Fall Meeting at Erie, it should be further noted that the four announced in the program proved of unusual interest to visitors. On Monday afternoon opportunity was provided to visit either the Erie Forge Company and the Erie Forge & Steel Co., or the American Sterilizer Company; and on Tuesday afternoon the choice lay between the General Electric Company's plant and that of the Hammermill Paper Company. Inasmuch as the writer of these notes found it

impossible to be in two places at the same time, he can comment only on the forge and foundry visit and that to the General Electric Company. Both were thoroughly enjoyed and acknowledgment of courtesies extended is gratefully made.

It is unfortunate that more critics of modern industry do not see for themselves at first-hand what goes on in modern manufacturing establishments, and that they do not attempt to absorb the creative and progressive atmosphere of such places and note the high quality of skill and manpower that is characteristic of them. Few examples of perfectly coordinated human and machine effort can compare, for example, with that to be seen in the forging of an enormously heavy crankshaft. Those who thrill to the coordinated performance of an orchestra under the baton of its leader would find a striking parallel in this industrial operation, besides which, for sheer fascination, Longfellow's village blacksmith is a weak substitute. In following through the various stages of fabrication of one of these gigantic and costly shafts the conviction grows that the high order of skill and intelligence required from top to bottom of the organization which undertakes to engage in such work is representative of modern industrial culture at its best and is thoroughly able to stand on its own feet in comparison with other cultures of modern life.

This conviction carries over into the steel foundry, where that homely philosophy of founders that what goes into the furnace comes out in the product takes on a universal as well as a very specific significance.

Moreover, contrasting, as opportunity was provided, this flowering of one of the oldest of man's crafts, the forging and casting of metal, with an excellent example of one of the newest of his industrial techniques, conveyor assembly of mass-production refrigerators, seen at the General Electric Company, further served to demonstrate high productive efficiency and coordination. As a contrast to a daily production of 1700 refrigerators, each as like the other as two peas, visitors were privileged to see in process of erection the first condensing steam-electric locomotive to be built in this country. Impressive as to size, as to fineness of contour, as to novelty in design, it was a reminder of the dynamic quality of modern industry and an example of the wealth in knowledge and experience mentioned by Mr. Smith in his dinner address.

A.S.M.E. Calendar
of Coming Meetings

December 6–10, 1937
Annual Meeting
New York, N. Y.

March 23–25, 1938
National Spring Meeting
Los Angeles, Calif.

May 4–6, 1938
Machine Shop Practice Meeting,
Rochester, N. Y.

June 20–24, 1938
Semi-Annual Meeting
St. Louis, Mo.

A.S.M.E. Executive Committee Meets at Erie

PREFACING the 1937 National Fall Meeting of The American Society of Mechanical Engineers, the Executive Committee of the Council of the Society met at 2:30 p.m., at the Lawrence Hotel on Sunday, October 3. There were present President James H. Herron, chairman; William A. Shoudy, James W. Parker, Kenneth H. Condit, members; William T. Conlon, advisory member (finance); Harvey N. Davis, president-elect; George A. Stetson, editor, and Frances Selig, assistant to the Secretary. Donald B. Prentice and Arthur J. Kerr, of the Committee on Local Sections, were present during the concluding portion of the Committee's session. H. R. Westcott, of the Committee, and C. E. Davies, secretary, were unable to attend.

Actions of the Executive Committee, of interest to members in general, are summarized as follows:

Trustees of Certificates of Indebtedness

Trustees of Certificates of Indebtedness were discharged with sincere thanks from further obligations and responsibilities. These trustees have been acting on behalf of the Society in connection with an issue of certificates of indebtedness through which the Society was able partially to finance its operations during the critical period of the depression. Improved finances have made it possible to redeem the certificates, with the exception of one for $500 yet to be returned for redemption.

Joint Meeting at National Metal Congress

The invitation of the American Society for Metals to cooperate with that society, the American Welding Society, the Wire Association, and the American Institute of Mining and Metallurgical Engineers in the National Metal Congress, Atlantic City, October 18, 1937, was accepted.

Recommendations on Member Reinstatement Approved

On the recommendation of the Board of Review, a number of statements of Society policy regarding reinstatement of dropped and resigned members were approved for adoption. The statements follow:

Reinstating Resigned Members (Policy in Effect to Sept. 30, 1938): When less than three years have elapsed between a member's termination of membership and application for reinstatement, reinstatement may be made by written request to the Board of Review accompanied by a check for annual dues prorated from the beginning of the month following date of request to the close of the fiscal year, no initiation fee is required. When more than three years have elapsed between such date of termination and application for reinstatement, then such member should file a new application which must be approved by the Committee on Admissions; likewise, no initiation fee is required, but payment of prorated dues from the beginning of the month following date of request to the close of the fiscal year should accompany the application.

Reinstating Dropped Members (Policy in Effect to Sept. 30, 1938): When less than three years have elapsed between the termination of membership (by dropped action) and application for reinstatement, such reinstatement may be made by written request to the Board of Review accompanied by a reentry fee of $10 plus prorated dues from the beginning of the month following date of request to the close of the fiscal year. When more than a three-year period has elapsed between the date of termination and application for reinstatement, then a new application must be filed, accompanied by a reentry fee of $10 plus prorated dues to the end of the fiscal year; approval must be obtained from the Committee on Admissions.

Dues-Cancellation Policy to Sept. 30, 1938: Upon submitting a statement as to liability to make payment, current dues and arrears may be canceled in whole or in part by the Council upon recommendation of the Board of Review. In arriving at recommendations, however, special consideration is to be given to tenure of membership and service in the Society, a study is to be made of applicant's ability to pay in the future, and, in fact, consideration is to be given to all personal elements concerning applicant. In addition to the foregoing, special consideration is also to be given to the amount of cancellations the applicant has previously requested and had granted; to a great extent a measure is to be used allowing a specified amount of cancellation for each year a member has paid dues, and where previous cancellations had been granted, deducting from the aforementioned calculation such cancellation credit already extended.

Policy for Resignation: A period up to six months will be allowed between the date dues are chargeable and date of request for resignation, and such dues that have accrued during this period of six months is to be canceled, allowing the member requesting resignation to resign in good standing. Where a period of six months or more has elapsed between the date dues were chargeable and the receipt of the member's request for resignation, the prorated dues must be paid by the member before he can resign in good standing. When such payment is not forthcoming, the member's termination of membership will come under the category of "dropped."

Policy for Dropped Action: Where it is definitely established that a member will make no further payment toward dues, the case is to be

presented to the Board of Review; and upon being satisfied the Board may recommend that such member, though owing less than two years' dues, be dropped instead of incurring an additional amount of useless bookkeeping and building up dues that are uncollectible.

Report on "Promise to Pay" Members

On Jan. 15, 1937, the Executive Committee of Council requested the Secretary to investigate the individual accounts of 250 members who owed three full years' dues or more but had promised to pay, and to expedite action on eight members whose resignations were pending. A report on the "promise to pay" group was made which showed that dues outstanding were $17,917.30, of which, as a result of a drive for payment of arrears, $3147, representing 61 members, has been or will have been paid. Thirty members are still being followed actively for payment and 157 members have been dropped from this group.

Actions Relating to Meetings and Program

The Executive Committee placed on record its formal vote approving the resolution of thanks adopted at the Semi-Annual Meeting, Detroit, Mich., May 17 to 21, 1937. It also confirmed approval of a letter ballot taking favorable action on the recommendation that the 1938 Annual Spring Meeting be held at Los Angeles, Calif., March 23 to 25. Approval was also voted of the recommendations of the Committee on Meetings and Program relating to the Towne and Thurston lectures for the 1937 Annual Meeting and the Calvin W. Rice lecturer for the 1938 Semi-Annual Meeting. These lecturers are:

Towne Lecturer, DR. ERNEST A. HOOTON, Anthropologist, Peabody Museum, Harvard University, Cambridge, Mass., on "Ape to Engineer, or the Simian Basis of Mechanical Science."

Thurston Lecturer, R. MERVIN HORN, Technology Photographic Department of Massachusetts Institute of Technology, Cambridge, Mass.

Calvin W. Rice Lecturer, W. R. BARCLAY industrial metallurgist, Mond Nickel Company, Ltd., London, England, on "Some Contributions of Metallurgy to Engineering Progress."

Approval was voted of the following policy for future meetings of the Society regarding the collection of money for entertainment or other purposes:

(1) It is expected that all excursions, entertainments, etc., be planned on a self-supporting or pay-as-you-go basis, except as below.

(2) Privately provided entertainment may be permitted provided it is definitely so described in the program.

(3) A small contingency fund may be raised to cover guarantees spoiled by bad weather, etc.

1937 Awards Announced

Upon recommendation of the Board of Honors and Awards the Committee voted approval of the 1937 awards as follows:

Holley Medal, FREDERICK G. COTTRELL, chemical and consulting metallurgist, Research Associates, Inc., Washington, D. C.

A.S.M.E. Medal, EDWARD P. BULLARD, president, Bullard Co., Bridgeport, Conn.

Worcester Reed Warner Medal, CLARENCE F. HIRSHFELD, chief of research, Detroit Edison Co., Detroit, Mich.

Melville Medal, ALFRED J. BUCHI, consulting engineer, Buchi Syndicate, Winterthur, Switzerland, for his paper on "Supercharging of Internal-Combustion Engines With Blowers Driven by Exhaust-Gas Turbines."

Junior Award, LESLIE J. HOOPER, Laboratory Assistant Instructor, Worcester Poly. Inst., Worcester, Mass , for his paper on "American Hydraulic-Laboratory Practice."

Research Agreement Renewed

Renewal was voted of the cooperative agreement between the Department of the Interior and The American Society of Mechanical Engineers for research on boiler-water treatment for the fiscal year July 1, 1937, to June 30, 1938, covering the work of the Subcommittee on Alkalinity and Sulphate Relations in Boiler Water Salines of the Joint Research Committee on Boiler Feedwater Studies.

Actions Relating to Local Sections

Upon recommendation of the Committee on Local Sections it was voted to extend the time within which student members may accept transfer to junior membership to Dec. 31, 1937.

D. B. Prentice, member of the Committee on Local Sections, spoke informally on the necessity of returning to the 100 per cent formula for local sections. While a larger appropriation is allowed in the budget for 1937–1938 than for the previous year, the increase in membership offsets the increase in allowance and the 75 per cent formula still applies. It was felt that the increase in membership justified an additional appropriation. The Executive Committee of Council advised Mr. Prentice that that matter will be given consideration and will be discussed at the next meeting of the Committee.

Unwin Memorial Committee Discharged

It was voted to discharge with sincere thanks the A.S.M.E. members of the joint Unwin Memorial Committee. This committee reported that its campaign to raise funds for a memorial to Dr. William Cawthorne Unwin, honorary member, American Society of Civil Engineers and The American Society of Mechanical Engineers, to commemorate the valuable services which Doctor Unwin rendered to engineering science, was closed on August 10, 1937, a draft for 100 pound-having been transmitted to the honorary treasurer of the Unwin Memorial Committee in London, representing contributions from 45 American engineers, and that its work was completed.

Allievi Elected Honorary Member

Sealed ballots of members of the Council on the election to honorary membership in the Society of Lorenzo Allievi, distinguished Italian hydraulic engineer, were opened and counted. All ballots being in favor, Lorenzo Allievi was declared elected an honorary member of the Society.

Deaths Reported

The death, on June 15, 1937, of Ambrose Swasey, honorary member and past-president of the Society, was reported. Representing the Society at the funeral services at Cleveland, Ohio, were John Lyle Harrington, Kenneth H. Condit, and E. Stanley Ault, and at Exeter, N.H., I. E. Moultrop, W. E. Wickenden, and C. E. Davies. The Committee requested Dexter S. Kimball and Joseph W. Roe to draft appropriate resolutions for record.

The death, on June 29, 1937, of Dr. L. L. Jeffcott, secretary, the Institution of Civil Engineers of London, was also reported, and the secretary of the Society was requested to draft a suitable resolution.

Appointments

Dexter S. Kimball and Joseph W. Roe were appointed to serve on a joint committee to prepare a memorial brochure for Ambrose Swasey. The committee will be composed of representatives of the American Society of Civil Engineers, The American Society of Mechanical Engineers, and the Engineering Foundation.

James H. Herron was appointed A.S.M.E. representative on the John Fritz Medal Board of Award for a period of four years.

Kenneth H. Condit was requested to study a

About Railroad Fares for the Annual Meeting

There will be no special reduced railroad fares to New York for the Annual Meeting in December. The railroad passenger organizations are not now granting any special convention rates, except to those traveling from one city *in coaches* in groups of 25.

The present reduced regular rates now in force for pullman travel are slightly higher than our convention rates for the last few years.

It is suggested that those members wishing to come in groups to the Meeting, at such distances where coach travel would not make it inconvenient, get in touch with the chairmen of their Local Sections, through whom arrangements may be made.

communication received from the Mechanical Engineering Division of the Society for the Promotion of Engineering Education offering cooperation in developing a program to further the education of engineering graduates.

The resignation was reported of Walter S. Finlay, Jr., as representative of the Society on the Board of Directors of the Thomas Alva Edison Foundation. No appointment to fill Mr. Finlay's place was made.

The following appointments to committees as well as to special representations were reported:

Library, John Blizard (4-year term); Professional Divisions, Harte Cooke (unexpired term of H. B. Reynolds) to December, 1940; Board of Honors and Awards, R. L. Sackett (unexpired term of R. H. Fernald), to December, 1939, Tellers of Election, W. F. Carhart, W. G. Hauswirth, E. J. Flavin; Special Research Committee on Thermal Properties of Steam, Max Jakob; Sectional Committee on Standardization of Wrought Iron and Wrought Steel Pipe and Tubing, Ludwig Skog; Petroleum Division Executive Committee, H. Weaver Smith, Clarence E. Sperry; Student Branches, 96 honorary chairmen; United Engineering Trustees, K. H. Condit (reappointed, 3-year term); Engineering Foundation Research Procedure Committee, W. H. Fulweiler (one year); National Management Council, K. H. Condit (unexpired term of J. W. Roe), to January, 1937; E.C.P.D., A. R. Stevenson, Jr. (reappointed three-year term); International Management Congress (Finance Committee), W. D. Fuller; Washington Award Commission of Western Society of Engineers, Bernhard Schroeder (2-year term); Jos. A. Holmes Safety Association, J. F. Barkley; Engineering Institute of Canada, 50th Anniversary Celebration, June 15–18, 1937, W. S. Atwood, C. E. Davies, N. R. Gibson, F. D. Herbert, J. H. Herron, Albert Laurie, R. E. MacAfee, Charles Penrose, H. L. Seward, T. Kennard Thomson, W. E. White, and H. H. Vaughan; Société Suisse des Ingénieurs et des Architectes, Centennial Celebration, Berne, Switzerland, Sept. 4–5, 1937, Frank A. Lockwood, International Congress of Engineers, Paris, Sept. 26–29, 1937, Wallace Clark, Henry S. Downe, H. A. Hopf, and Geo. B. Karelitz.

Exhibit of Photography for Engineers

at 1937 A.S.M.E. Annual Meeting

AS NOTED in the September and October issues of MECHANICAL ENGINEERING, members throughout the country are invited to submit pictorial or technical prints for the forthcoming exhibition. Prints should be about 8 × 10 in. and simply mounted on plain, light-colored cards about 15 or 16 by 20 inches. Prints should be received between Nov. 1 and Nov. 20, by John F. Guinan, Annual Photographic Exhibit, A.S.M.E., 29 West 39th Street, New York, N. Y.

New Sanding Data Presented at Wood Industries Meeting in Grand Rapids

THE tenth annual meeting of the A.S.M.E. Wood Industries Division held in Grand Rapids, Mich., on October 8 and 9, was a most successful one. There was a registered attendance of 115 and the sessions averaged from 45 to 70.

Hot-press gluing using phenol-resin bonds and the more recently developed resins employing lower temperatures, aroused considerable interest because of the wider fields they have opened for plywood and laminated-wood utilization. A recent application of this method to tennis-racquet manufacture was described wherein several wood laminations, bonded by a completely water-proof glue line, were bent into shape and glued in one operation. Problems of hot-press operation, means and time required for heating, quantities of glue used per unit surface, and difficulties of obtaining complete bonding because of nonuniform veneer thickness were all subjects of interested discussion.

Wood-Sanding Data

Two papers on wood sanding placed on the Society's records for the first time data on relationships between pressure, speed, and cutting rates when using coated abrasives. One of the papers was prepared from the point of view of the manufacturer of coated abrasives, the other of the user, but both covered the same range of operating conditions, thus increasing their value. The investigations have established within practicable limits the most economical range of belt speeds for stroke sanders.

From the Forest Products Laboratory and Michigan University came two papers on the machining of wood, constituting reports on the first of a series of investigations conducted at these institutions. They gave specific data on the suitability of several wood species to planing and the results of exploratory tests looking toward the establishment of wood-machinability ratings by planing and drilling tests.

During the meeting the subcommittee on the machining of wood met twice and secured the hearty agreement of a group of wood-machinery manufacturers to cooperate in the machining work at the Forest Products Laboratories and the University of Michigan by supplying experimental machines. Arrangements were also made to prepare translations of several foreign papers on the machining of wood.

Excellent Talks by F. E. Seidman and A. P. Haake

The luncheon talk by F. E. Seidman on "The Economics of the Furniture Industry" and the dinner speech by Dr. A. P. Haake on "Human Engineering" were excellent expositions of current economic and social conditions. Mr. Seidman discussed the causes of the present generally restricted purchasing of furniture. Dr. Haake spoke on the fallacies of restricting production as a means to general economic welfare and on the responsibilities of capital, management, and labor for maintaining a high standard of living by increased production.

Excellent arrangements for hotel and meeting accommodations, inspection trips to furniture factories, and entertainment testified to the careful planning of the local committee, C. B. Norris, A. S. Kurkjian, R. E. Klise, and L. A. Cornelius, all of the Peninsula Section of the A.S.M.E.

R. H. MCCARTHY.[1]

[1] Member of Executive Committee of Wood Industries Division.

Draft Completed of Chapter on Indicating Gages

Criticism and Comment Invited

THE importance and frequent use of pressure gages in the testing of power-plant equipment has prompted the A.S.M.E. Power Test Codes Committee on Instruments and Apparatus to give special care to the preparation of its chapter on the various types of indicating gages which are employed for this purpose.

A tentative draft of this chapter is now completed and the Committee will welcome the criticism and comment of it by members of the Society and others interested. Copies may be obtained by addressing the Power Test Codes Committee, A.S.M.E. headquarters.

The Committee in charge of this part of the Power Test Codes activity consists of C. F. Hirshfeld, chairman, W. A. Carter, secretary, C. M. Allen, E. G. Bailey, H. S. Bean, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. W. Johnson, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, R. J. S. Pigott, E. B. Ricketts, W. A. Sloan, and R. B. Smith.

This chapter includes sections dealing with (1) Bourdon, bellows, and diaphragm gages, (2) gage calibration apparatus, (3) calibration of Bourdon, bellows, and diaphragm gages, (4) dead-weight gages, and (5) calibration of dead-weight testers and gages.

Pressure and vacuum gages, as ordinarily used, are instruments for indicating the difference in pressure between atmospheric pressure and the pressure in a pipe or vessel. In the case of the Bourdon, bellows, and diaphragm gages the pressure in question is transmitted to the interior of an elastic chamber and the resultant motion of a pointer gives the gage reading. The exterior of the elastic chamber is usually at atmospheric pressure.

Owing to the necessity for a large multiplication of the movement of the walls of the elastic chamber, and to the possibility of slight variations in this movement, such gages

require frequent calibration which is made with gage testers or mercury columns.

Dead-weight gages are similar to dead-weight gage testers, and may be used directly for accurate pressure measurements thus avoiding the necessity for calibration.

"Best A.S.M.E. Meeting" Held by Los Angeles Section

THE following letter has been received at headquarters from the chairman of the Los Angeles Section, William Howard Clapp, in which he tells of an enthusiastic meeting recently held by that Division.

"The best A.S.M.E. meeting I ever attended." Such was the enthusiastic comment heard on every hand when our get-together meeting adjourned last night (September 16). Ninety-two sat down to dinner, a remarkable record as the thermometer was 101 yesterday and has been hovering around the hundred mark for a week.

Personal letters to all of the old-time members had brought out a goodly number. Five of these spoke briefly of pioneer days of A.S.M.E., speeches being limited to ten minutes each. Spencer Miller, '88, vigorous and incisive, told what the fellowship and interest of the founders of the Society had meant to him as a young engineer and urged the cooperation of the older and younger members. Ernest N. Wright, '89, told of his acquaintance with "Fred" Taylor and of Taylor's great enthusiasm and his lack of any self-interest in his service to mechanical engineering. At the close of this fine talk he presented the Section with a framed photograph of Frederick W. Taylor, for which we will have a suitable inscription prepared in commemoration of the donor and the occasion. C. V. Kerr, '92, spoke on the contribution of great minds to the advancement of mechanical engineering; and Edward Thomas Adams, '99, made John Sweet live again in our minds as he paid tribute to his kindliness, his integrity, and his uncommon common sense. From San Diego came John L. Bacon, '99, who spoke briefly of Dr. Sweet's straight-line engine.

These talks were not "old men's ramblings." They were vigorous and intensely interesting. There followed a short musical intermission, very funny and greatly appreciated, after which the key speaker of the evening was presented. Few men in public life, who have thought deeply and soundly on the perplexing problems of today, have such a happy gift for clear and enthusiastic presentation as Prof. Paul Perigord of the University of California at Los Angeles. He spoke of the contribution of engineering to civilization, of the great value of this contribution, and of the value to society of the trained engineering mind in helping to solve the problem of adjusting production, distribution, and employment. He spoke of the greater difficulty of the distribution problem, since production is a material problem while solving the problem of distribution depends largely upon education and spiritual growth. He urged the need of enlightened altruism and praised the farsighted employers who realize that a better distribution can keep the wheels of progress turning. He praised the spirit of democracy and the democratic principle of checks and balances, and reiterated his belief that here in America, in spite of our present perplexities, there will develop a system of government which will preserve liberty and initiative and advance the material welfare of all. It was truely a magnificent appeal to have faith and to carry on.

Writing this out this way it may sound like a "preachment." Call it that, it was impressive and inspiring and *fine*, the sort of thing that makes membership in the Society a call to service and gives point and purpose to living. At the conclusion of his 45-minute address the members rose spontaneously and applauded for several minutes.

We are on our way to what I trust will be a most happy and successful year. As usual our "hindsight" is better than our foresight. While we finished promptly at ten o'clock, there were the makings of two splendid programs with fine discussions which were here precluded. "Live and learn."

The splendid enthusiasm of the Los Angeles Section promises a successful National Spring Meeting of the Society in Los Angeles, March 23 to 25, 1938.

Junior Group Activities

Program for Chicago Juniors Gets Under Way

THE THIRD phase of Junior-Group activities in the Chicago Section opened with the fall season this year. As in the last two years the ideal is to offer A.S.M.E. Junior members a larger part in the activities of the Chicago Section. The program each year has been carefully developed to meet the needs of the young engineer during that period of his professional life preceding his becoming actually identified with the professional work of the Society.

Every man who has attended the meetings of the Chicago Junior Group during this development period has unwittingly contributed to the policy being followed in the 1937–1938 program. From their manifold suggestions and expressed desires has appeared a group of guideposts to indicate the present trend in Junior thought.

Desire for Broader Acquaintanceship

The first of these is the desire for broader acquaintanceship among the members of the Society. The average Junior member who enters Section activities for the first time knows at most only two or three members. Participation in Junior activities with men of his own age and experience gives him an opportunity to create a larger circle of friends in the Society, so that when he later takes an active part in the professional work he knows and is known to a considerably larger group. The benefits of professional association, somehow, are greater in an atmosphere of mutual acquaintance.

Each year the professional divisions of the Chicago Section have cooperated wholeheartedly in assisting development of Junior activities. The completed Senior-member program for 1937–1938 includes meetings that will be of special interest to Junior engineers. On practically all of the professional division committees, Junior members are assigned to assist in program work. Further, to develop the wider-acquaintance ideal, Junior members have been invited to be joint sponsors of meetings of the professional divisions. It is hoped that through these joint meetings a better understanding of the professional work will be obtained and that wider acquaintance among the entire membership of the Chicago Section will result.

The Work of the A.S.M.E.

The second point of prime importance is that of obtaining a clearer understanding of the work of the National Society, its organization, and activities. Those members of the Society in the Chicago area who are members of National Committees or who are officers of the Society will be drawn upon to explain the work of the A.S.M.E.

Finally, it is necessary that opportunity be offered Junior members through administrative duties in connection with Junior activities and through committee and technical discussions at their own meetings to discuss the problems and subjects that will eventually lead to intelligent and worth-while participation in the activities of the Chicago Section and the National Society.

Junior members in the Chicago area are afforded all of these opportunities by attending Junior meetings. The A.S.M.E. can certainly become more than an engineering journal to any junior engineer who will avail himself of the chance to participate in the 1937–1938 annual program of the Chicago Section.

As an opening gesture in this direction the October meeting proved a tremendous success. A. M. Houser, Sr., engineer of standardization, Crane Company, Chicago, presented a most interesting talk on "Creation of American Standards." The questions that followed Mr. Houser's talk indicated the intense interest of junior engineers in a topic of this kind. A surprising note was the rather large percentage of older members in attendance.

P. P. Ficnerski, Chairman of Milwaukee Juniors

AN active program is being formed for the coming fall and winter for the Junior Group of the Milwaukee Section.

Several board meetings have been held during the summer under the direction of the newly elected Junior chairman, P. P. Ficnerski, at which plans were discussed for technical classes aside from the regular meetings, monthly meetings, and for the securing of membership.

At the final meeting held last spring the

Junior members elected for their chairman, Mr. Ficnerski, and for secretary R. L. Homsher, together with the following Board members: T. F. Esserkaln, J. H. Goetz, J. W. Krueger, C. Malischke, and C. J. Stessel.

E. V. Erickson to Address Metro Juniors on Air Conditioning

"WHAT the Air-Conditioning Industry Expects From the Engineer" will be the subject of the principal November meeting of the Metropolitan Section Junior Group, A.S.M.E. The speaker will be E. V. Erickson, manager of the New York export office of the Carrier Corporation, and the meeting will be held on Tuesday evening, November 9, at 7:30 in Room 1101 of the Engineering Societies Building, 29 West 39th Street, New York, N. Y.

Mr. Erickson will explain and describe the science of air conditioning both as to concept and various types of equipment involved in practical problems. His talk will continue with a summation of what the industry expects from the air-conditioning engineer, and conclude with a description of its requirements of the general engineer in the field. A question period will follow the address.

Mr. Erickson's talk is sponsored by the newly formed Air-Conditioning Seminar of the Metropolitan Section Junior Group. Over 150 members of the Group expressed interest in the establishment of the seminar, which is in charge of S. Davidson, of the Armo Cooling and Ventilating Company, Inc., of New York, who will preside at the meeting.

"What Is Your Objective?"

Query Put to Junior Group

"WHAT Is Your Objective?" was the question put to those who attended the Junior Group meeting in the Engineering Societies Building, New York, on October 5. The speaker was R. M. Gates, vice-president, Superheater Company and the Combustion Engineering Company, Inc.

Mr. Gates asked the question in reference to the various stages of an engineer's life from high-school days to later life, and made both general and specific suggestions in connection with the problems encountered. He emphasized the fact that his observations must be studied by each individual with his own problems in mind.

Appreciation of the problems of others, temperament, the need for obtaining broad experience, avoidance of specialization at too early an age, the desirability and necessity of keeping well-posted on industrial progress, the knowledge of where to get required information, recognition of personal aptitudes and limitations, the need for common sense as well as knowledge of theory, and cooperation with others were among the many points discussed in the course of Mr. Gates' talk.

The curse of the engineering profession today is lack of knowledge on the part of executives of the answer to the question, "What Do Things Cost and Why?" Mr. Gates declared in emphasizing the need for building up of a broad foundation of experience in fields other than pure engineering if young engineers are to hope to be eligible to fill positions of responsibility in the future.

He also stressed the desirability of obtaining a Professional Engineers' License, in view of the increasing importance of a licensing program, and the requirement that supervising engineers of the future will have to hold such status.

Students Are Welcome at Junior Meeting

MANY student members of The American Society of Mechanical Engineers do not realize that they are welcome to attend meetings of Junior Groups as well as those of senior members. Several Junior Groups have appointed committees or subcommittees to study means of emphasizing this fact to undergraduates.

Various means are being used. In some cases Junior Group representatives attend Student Branch meetings to point out the purpose and program of the Society. Sometimes alumni are asked to get in touch with individual students or officers of Student Branches. Smokers and dinners for both Junior and Student Members have been successful.

Undergraduates are urged to take advantage of their privilege of attending Society functions and meeting other students as well as practicing engineers.

Ontario Junior Group Elects Officers

AT A recent meeting of the Junior Group of the Ontario Section, the following men were elected to serve on the Junior Executive Committee for the coming season: Chairman, H. G. Hill; secretary, F. Truman; committeemen, T. O. O'Neil and G. E. Smith; Senior representative, D. F. Cornish.

The group, scheduling its monthly meeting between the senior section meetings, will follow last year's policy of promoting student- and junior-member participation in the senior meetings and discussions.

At present the juniors are completing arrangements for a special joint meeting with the senior organization at which the younger members will handle the entire proceedings. This form of Junior participation in senior activities is becoming very popular in those sections in which it has been inaugurated.

T. H. Beard Addresses Juniors at Bridgeport

T. H. BEARD, vice-president of the Dictaphone Corporation, opened the Junior Group activities of the Bridgeport Section on October 14 with a round-table discussion on "Industrial Organization and Management." Mr. Beard is active in local, state, and national Society work, an authority on industrial organization, and particularly interested in professional and civic problems.

The aim of this Junior Group is similar to that of many others—to help the junior member through the transition period from college life to industrial recognition by helping him to meet and know not only junior members but senior members, leaders in industry. Management, particularly, will be stressed.

Active members of the Executive Committee are A. H. Beede, chairman; M. W. Wilterdink, vice-chairman; D. E. Steer, secretary-treasurer; C. A. Buss, D. J. Lorillo, C. R. Libby, D. G. Thompson, and W. E. Viscusi.

Members' Room Open Before Evening Meetings

THE members' room at the headquarters of the Society on the eleventh floor of the Engineering Societies Building, New York, is open for use during the evening hours preceding Junior Group Meetings. This arrangement was made through the courtesy of the Metropolitan Section and the officers of the Society to provide a meeting place for those members who would not otherwise find it convenient to wait for the meetings. It also provides another opportunity for Juniors to become better acquainted with each other as well as with those senior members who so often attend the Junior meetings.

E. L. Midgette Addresses Baltimore Juniors

THE Junior Group of the Baltimore Section of the A.S.M.E. began its season on October 26, at the Johns Hopkins University, when Ernst L. Midgette, instructor in mechanical engineering at the University, talked on "Vibration Prevention in Engineering."

The Executive Committee of the Junior Group plans to classify the members of the Group according to subject interest and occupational relationship. This will enable the individual groups to present their subjects either in unit paper or in debate form.

Tri-Cities Juniors Have Busy Meeting Schedule

THE Junior Group division of the Tri-City Section of the Society has been most active in the two years of its existence.

Certainly, if proof were needed of these activities it is furnished by the list of meetings sent in by A. S. Lundy, junior chairman. This interesting schedule gives 16 dates starting with November 4, 1937, and ending with June 9, 1938. (There are four additional meetings listed for the design section of the Junior Group.) In it are covered such subjects as the improvement of relations between young engineers and industry, the connection between manufacturing and selling, the experimental development of a machine, building highways, and several inspection trips.

With the Student Branches

Branch Officers and Committee Chairman

ARKANSAS BRANCH members elected Lamar Attwood and William Mapes to fill the vacant position of vice-chairman and reporter, respectively. . . . . NEW YORK UNIVERSITY BRANCH officers for the 1937–1938 year are Leonard K. Swenson, Ralph Meuller, and Samuel Nooger . . . . . Chairman John Vye of NORTHWESTERN BRANCH announces the appointment of the following committee chairmen: Program, Cliff Becher, Papers, Leonard Munson and Membership, Harry Storms . . . . . TEXAS A. & M. members chose I. T. Yardley to fill the vacant vice-chairmanship, R. C. Wade as reporter, R. S. Weaver as program-committee chairman, and J. C. Morris as attendance-committee chairman . . . . . At FLORIDA BRANCH E. E. Bisson was chosen as chairman of the membership committee. Mr. Klotz was elected to the vacant office of vice-chairman . . . . . ALABAMA POLY BRANCH starts the new term off with the following set of officers: Roy Dodge, H. B. Pollock, Gore Kemp, and Franklyn Ward as publicity agent . . . . . At the first meeting of WASHINGTON UNIVERSITY BRANCH, Norman Hartman was elected to assume the important job of treasurer was declared open when the member elected to the office last spring did not return to school this fall.

First Fall Meetings

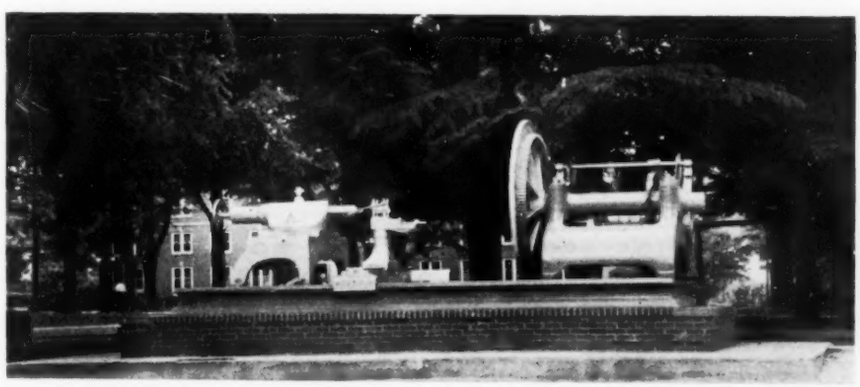
KANSAS UNIVERSITY BRANCH first meeting of the new school year was a smoker open to all mechanical- and industrial-engineering students . . . . . Chairman Graham Finley of VANDERBILT BRANCH gave a short talk to the 37 members and visitors about the advantages of being a member of the branch . . . . . NEW YORK UNIVERSITY BRANCH opened its first meeting with plans to increase membership by 100 per cent and to sponsor a contest among the members later in the year . . . . . Hot coffee and rolls were served after the first meeting of the COLORADO STATE BRANCH . . . . . CLEMSON BRANCH used the first meeting as a means to invite students to become members . . . . . ARKANSAS BRANCH members completed a great deal of business at their first meeting ..... NORTHWESTERN opened its first meeting with a talk by Alex Bailey, chief operating engineer of the Commonwealth Edison Company, vice-president and senior counselor of the A.S.M.E. . . . . At the first meeting of NEW HAMPSHIRE, ten seniors were present to welcome eighteen juniors into the branch . . . . . Martin True, chairman of the TEXAS TECH BRANCH, opened the first meeting by briefly outlining the activities scheduled for the coming year, such as, interesting laboratory experiments, visits to local plants and a few social gatherings . . . . . U. S. C. BRANCH members discussed the coming year's activities . . . . . The first meeting of ROSE TECH BRANCH was opened by chairman Jack Merrifield with a short speech of welcome to members and visitors . . . . . TEXAS A. & M. had 46 members and 4 visitors at its first meeting . . . . . Chairman Fred T. Gear gave the members of VERMONT BRANCH an idea of what the branch can do for them . . . . . The first meeting of the FLORIDA BRANCH was for the purpose of making plans for the coming year and therefore was only open to the officers. The meeting of all members was held two days later . . . . . ALABAMA BRANCH at its first meeting had fifteen new men pay their membership dues . . . . . Members of NEBRASKA BRANCH finished up their first meeting by adjourning to the foundry where "varying amounts of soda were consumed" . . . . . Our congratulations to the UNIVERSITY OF CALIFORNIA for having 165 present at their first meeting . . . . . The first meeting of WASHINGTON UNIVERSITY BRANCH was called to order by chairman John Toedtman . . . . . KENTUCKY BRANCH members at their first meeting voted to assess themselves twenty-five cents each in order to build up a reserve fund for their organization . . . . . A. E. Boyer Britt reports that at the first meeting of the MISSISSIPPI STATE BRANCH, there were so many new members that all the available application forms became exhausted. One of the new members intending to join is Miss Cora McDonald.

Talks by Student Members

WEST VIRGINIA BRANCH had a very interesting meeting when talks were given by Albert Fisher on air conditioning, Arthur Ritchie on the Ohio River, Charles Swing on air forces of European countries and Robert Abbott on warfare by fire . . . . . Bob Daniels presented a paper entitled "Gasoline Information for Motorists" before the members of the ARKANSAS BRANCH . . . . . Jack Merrifield, chairman of ROSE TECH BRANCH, started off a series of interesting talks by members by giving a paper on "The Prevention of Failure in Ferrous Materials by Magni-Flux Testing" . . . . . A fine talk was presented to the members of the UNIVERSITY OF CALIFORNIA BRANCH on oil production in the Kettleman Hills field by W. R. Walden who illustrated his paper with motion pictures.

This and That

Samuel Nooger, secretary of the NEW YORK UNIVERSITY A.S.M.E. BRANCH at University Heights, New York City, requests that other student branches send him any ideas or plans for making meetings more interesting . . . . . COLORADO STATE BRANCH in order to boost membership and the treasury has invited freshmen and sophomores to join as associate members which gives them the privilege of participating in local meetings and inspection trips. Since money collected from associate members does not have to be sent to National Headquarters, the branch is that much ahead financially . . . . . Chairman T. Herlihy of NEW HAMPSHIRE BRANCH appointed a social committee to plan an engineering dance in conjunction with the A.S.C.E. and A.I.E.E. student branches. The members of the committee are Carl Rice, David Kerr, and Fred Johnson . . . . . At TEXAS TECH, Max Nuttall outlined a plan to increase the branch membership from twenty-five to fifty or more members. Lester Mueller, secretary of the branch is hereby requested to furnish us with full details about the plan and its ultimate success . . . . . Anytime the ALABAMA POLY BRANCH runs out of speakers for any of its meetings, it can call upon Prof. Hixon, the honorary chairman not only to give a fine talk but to perform "sleight of hand card tricks" . . . . . WASHINGTON UNIVERSITY BRANCH is planning an inspection trip to the Anheuser-Busch Brewery. Gentlemen, is that the place where they make beer?



Confederate Gun Lathe Now a Monument

(A lathe, perfectly attuned and capable of precision work even today, although used to drill the bore of many antiquated cannon in the Confederate Gun Works at Selma, Alabama, was recently presented to the Alabama Polytechnic Institute by the Tennessee Coal, Iron & Railroad Company, and now adorns the campus at Auburn, Alabama, a few feet from the main administration building. The Tennessee Company acquired it many years ago from the old Linn Iron Works where it was used to turn locomotive tires. Since 1929 when the Tennessee Company came into possession of this lathe, it had been stored at the Fairfield Works and when the subject of its disposition came up last November, its historic interests warranted perpetuation and Dean Wilmore of the School of Engineering, Alabama Poly., promptly accepted it as a gift.)

The Members' Page

A Forum for Frank Discussion by A.S.M.E. Members

Mechanical-Engineering Education

THE MEMBERS' PAGE:

I have just read Professor Eidmann's forceful letter[1] on the subject of continued mechanical-engineering education for Junior members of the Society. For eight or nine years I have been following the work of the American Society for Metals, formerly the American Society for Steel Treating, with its educational program and have given lectures in this course.

Here in Los Angeles the course attracts from 100 to 150 paid registrants each year, many of whom become members of the Society. Enthusiasm for the course has grown since the Parent Society has developed a well-thought-out and coordinated set of lectures. I am sure that similar short courses would be most helpful for mechanical engineers. I feel very strongly that something of this kind must be worked out for our Junior members if we are to hold their interest and eventually bring them into the Society as enthusiastic working members. I am sure that we could get able, qualified lecturers for presenting such courses if the courses were prepared and coordinated. We have a situation here which I expect is fairly representative of other sections in which over 40 per cent of our members are Juniors, most of whom joined within the last three years. Few of them attend meetings and many leave the Society to join the growing list of more specialized organizations.

WM. HOWARD CLAPP.[2]

THE MEMBERS' PAGE:

The A.S.M.E. should be a leading factor in mechanical-engineering education. At present the need of such education is definite. Many feel that education ends with graduation from college. My contention is that it is only a foundation.

When one enters the business or commercial world, education perhaps of a different nature should continue. This education might be along specialized lines or broad engineering fundamentals but should stress the practical viewpoint.

At present, I am the A.S.M.E. representative sponsoring a Review Course in Structural Planning and Design for applicants of Professional Engineers' Licenses. I have been told by those taking the course that it is worth many times the fee, not only for the benefit derived in knowledge along the particular subject, but more for the mental exercise the course furnishes.

GEO. J. NICASTRO.[3]

THE MEMBERS' PAGE:

Professor Eidmann's post-educational program for young engineers is commendable for large Local Sections but does not seem to be sufficiently individual for the small ones. The range of topics suggested is especially good, and many of them could be studied with profit by men in diversified industries.

To make the program apply to small Local Sections, I would like to see several young engineers placed under the direction of an older man who would contact these men personally and ask them to take part in a reading and study program. The course would be supplied by the Society, its actual application being left to the Director's discretion after consultation with his group.

Such a program could only be made effective by constant and aggressive action of the Engineers' Council for Professional Development in checking the work actually done by each Local Section. The benefits of the splendid work of the E.C.P.D. could, by this means, be made to contact both the older and the younger engineers, and its program has then passed the crucial test: Can it reach every member or at least a majority of all members in the profession?

JENSEN C. CLAUSEN.[4]

THE MEMBERS' PAGE:

My experience with engineering society meetings of both young and older members has led me to believe that a comprehensive series of lectures would not draw a sufficient number of men to the meetings to make them worth-while. This experience is the result of active association with the local Engineers' Club and A.S.M.E. Sections.

My thought is that more deliberation in planning should be taken in arranging the regular monthly meetings of the Local Section, so that a greater variety of subjects may be discussed at each meeting with a definite point in view. To help the Local Sections in planning such a program a committee on education, appointed by the Council, would be able to make valuable recommendations. As for printed reports of the technical meetings held by the Local Sections, any outstanding paper should be submitted to the editor of MECHANICAL ENGINEERING for publication.

I agree with Mr. Eidmann that the A.S.M.E. rightfully should be a leading factor in mechanical-engineering education. The Local Sections can play an important part in furthering a definite educational program. Due either to neglect on the part of the Local Section program committees or to lack of cooperation and encouragement from the national society, I believe many of our local bodies have fallen down in their obligation to their members. In consequence of the widely spread Local Sections of A.S.M.E. some means of coordinating the educational program should and could be built, supported by our Society dues.

FRANK H. WILLIAMS.[5]

THE MEMBERS' PAGE:

A short series of lectures that would be open to the members of the A.S.M.E. or similar societies, as suggested by Professor Eidmann, would be appreciated by the writer. I attended several of the courses, given for the unemployed engineers, at the Engineering Societies Building during the early part of the depression. I might not have been able to pass an examination in the various courses when they ended, but I certainly did get much worth-while knowledge, information, and enjoyment from them.

C. BENJ. BRUSH.[6]

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[1] "Mechanical-Engineering Education," MECHANICAL ENGINEERING, vol. 59, June, 1937, p. 471.

[2] Professor of Machine Design, California Institute of Technology, Pasadena, Calif. Chairman of A.S.M.E. Los Angeles Local Section.

[3] Proposition Engineer, Combustion Engineering Company, Inc., New York, N. Y. Mem. A.S.M.E.

[4] Foreman, American Can Company, Seattle, Wash. Jun. A.S.M.E.

[5] Engineering Department, Delco-Frigidaire Conditioning Division, General Motors Sales Corporation, Dayton, Ohio. Jun. A.S.M.E., Secretary, Dayton Section.

[6] Secretary, Treasurer, and Factory Manager, Modern Brands, Inc., Newark, N. J. Mem. A.S.M.E.

Other Engineering Activities

A. B. Clemens Honored by Associates

A. B. CLEMENS

A. B. CLEMENS, a member of the A.S.M.E. since 1904, and director of the Mechanical Schools, International Correspondence Schools, Scranton, Pa., for sixteen years a member of the Pennsylvania State Registration Board for Professional Engineers, has been presented by his colleagues on the board with a resolution expressing their appreciation of his long and meritorious service.

Mr. Clemens was selected by Governor Sproul to serve as one of the five members of the first board appointed, following enactment by the Pennsylvania legislature, in 1921, of the law providing for the registration of professional engineers and surveyors. In 1929 he was elected president of the board, and continued to hold this office for seven years. He has served under five successive administrations.

M.I.T. and Harvard Hosts for 1938 Congress of Applied Mechanics

THE program for the fifth International Congress for Applied Mechanics to be held in Cambridge, Mass., September 12 to 16, 1938, will fall under the general heads:

(1) Structures, elasticity, plasticity, fatigue, strength theory, crystal structure.

(2) Hydro and aerodynamics, gasdynamics, hydraulics, meteorology, water waves, heat transfer.

(3) Dynamics of solids, vibration and sound, friction and lubrication, wear and seizure.

Besides communications from members of the Congress it is planned to have a number of general lectures, as at former Congresses, for which the separate technical sessions will be suspended.

The Congress will be held in the lecture rooms of the Massachusetts Institute of Technology, and at its close members are expected to proceed to Washington, D. C., where a program of sight seeing and visits to government laboratories will be arranged.

It is probable that other trips will be arranged for those members from abroad who may wish to visit other cities.

Dormitory and boarding facilities will be made available by Harvard University.

Applications for Engineers' Licenses Show Great Increase

IN THE fiscal year ended June 30, 1937, approximately four times as many applications for licenses were reviewed by the New York State Board of Examiners of Professional Engineers and Land Surveyors as in the 1935 fiscal year and 62 per cent more than in the intervening period. The Board considered a total of 7173 applications at its 15 meetings in the last fiscal year, held 1795 for written examination, rejected 1510, held 769 for further consideration, and recommended that licenses be issued to 3099. All of these applications did not come before the Board for the first time and the total number given includes some duplications where the same application may have been considered on one or more occasions.

Only one written examination was held in the last fiscal year. At this examination, which was in February, 1937, the number of candidates who appeared was 603, and of these 477 were recommended for licenses, 41 were rejected, and 85 are to receive another examination in one subject. The percentage of those passing the examination, 79, compares with 80 and 76 per cent in the last two previous years.

On June 30, 1937, the number of professional engineers who were registered and hence legally entitled to practice was 8220, those entitled to practice land surveying numbered only 753, and licenses to practice both professional engineering and land surveying had been issued to 2936 more. This total of 11,909 is approximately 66 per cent of the 18,000 licenses issued since the licensing law was originally enacted. The difference between these two figures represents those who were granted a license at one time and either failed to comply with the law regarding annual registration or have died.

E.C.P.D. Holds Fifth Annual Meeting

C. F. Scott Elected Chairman and H. P. Hammond Vice-Chairman

DIVERGENT views on the rate of progress made to date by the Engineers' Council for Professional Development were expressed at the fifth annual meeting of the Council held at the Engineering Societies Building, New York, N. Y., on Sept. 30 and Oct. 1, 1937. Some observers expressed the opinion that accomplishment to date had exceeded expectations; others that it had been disappointing. However, the fact was brought out that the Council is a policy-forming and advisory group, so that its objectives in respect to professional development must be attained through the medium of its constituent and related bodies. In view of the youth of the Council, the difficulty of bringing to all members of the engineering profession a knowledge of its existence and objectives and an understanding of its advisory function, it was generally conceded that in the very real accomplishments in accrediting engineering-college curricula and in providing aids to student counselors and young engineers, its progress had been satisfactory.

Suggested Future Activities

The meeting started with a preliminary session on Thursday at which C. F. Scott, chairman, E.C.P.D., read a report in which he attempted an evaluation of ideals and suggested activities for the future. Informal discussion on the work of the Committees on Student Selection and Guidance and on Professional Training, and consideration of means by which papers relating to the objectives of E.C.P.D. might be given greater publicity occupied the session until it was adjourned for dinner, where further discussion took place.

On Friday morning, reports of Committees on Student Selection and Guidance and on Professional Training were presented by R. L. Sackett and Ovid W. Eshbach, the respective chairmen, and were approved. D. B. Steinmann presented the report of the Committee on Professional Recognition, and, following a thorough discussion, the committee was asked to give further study to its report with a view to its revision and resubmission at the next meeting.

At the afternoon session to which no visitors were admitted, consideration was given to the report of the Committee on Engineering Schools which was principally concerned with the accrediting of curricula in the engineering colleges of the nation. As of Sept. 30, 1937, the Committee on Engineering Schools, through its delegatory committees had visited 127 institutions of the 133 who had invited visits for the purpose of accrediting. A total of 617 individual curricula were inspected in the institutions. Civil, electrical, and mechanical engineering curricula provided 119, 116, and 112 separate curricula of the 617 total. The program of the Committee on Engineering Schools in accrediting engineering curricula was partially completed a year ago when announcement was made of the accredited curricula of the schools located in the New England and North Atlantic States area. Since that time the entire country has been covered, and a complete list of 373 curricula in the 127 schools which were visited has been announced. This list will be published in MECHANICAL ENGINEERING for December, 1937.

At Friday's meeting Charles F. Scott, professor emeritus of electrical engineering, Yale University, was elected chairman of the En-

gineers' Council for Professional Development and H. P. Hammond, Dean of Engineering, The Pennsylvania State College, was elected vice-chairman. A. B. Parsons, Secretary, American Institute of Mining and Metallurgical Engineers, and C. E. Davies, secretary, The American Society of Mechanical Engineers were elected secretary and assistant secretary, respectively, of the Council. Chairmen of committees were reelected as follows: Student Selection and Guidance, R. L. Sackett; Engineering Schools, K. T. Compton; Professional Training, O. W. Eshbach; Professional Recognition, C. N. Lauer.

Reappointments to the Council announced were J. P. H. Perry, A.S.C.E., and A. R. Stevenson, Jr., A.S.M.E.; new appointments, W. B. Heroy, A.I.M.E.; B. F. Dodge, A.I.Ch.E.; and R. E. Doherty, S.P.E.E. Appointments to committees announced were as follows: Committee on Student Selection and Guidance, H. L. Davis and R. L. Jacobs; Committee on Engineering Schools, G. M. Butler and I. C. Crawford; Committee on Professional Training, S. D. Kirkpatrick and A. R. Stevenson, Jr.; Committee on Professional Recognition, W. B. Heroy, H. S. Rogers, and W. I. Slicher (alternate for J. W. Barker).

American Engineering Council

The News From Washington

Activities of Government Agencies

WORKS Progress Administration appears to be the last of the emergency-spending agencies created by President Roosevelt in the desperate days of 1933 when the nation turned to public spending on a colossal scale for those things which did not require a market until the country could develop purchasing power and restore balance to the production structure. Some of the other agencies are still in existence but W.P.A. is the only one open to applications for projects and in a position to accept additional financial responsibilities. W.P.A. obligations are numerous, but it is still spending at an annual rate of $1,500,000,000.

Engineers have had much to do with C.W.A., F.E.R.A., and W.P.A., and while that organization, under the three names, has been eminently successful in doing what it set out to do—create immediate employment for the heads of relief families—many well-informed engineers objected when W.P.A. invaded the construction field on "a force account" basis, and when it relieved the political subdivisions of their architectural and engineering work. As the requirement of 30 per cent local contribution for materials, the $25,000 job limitation, and other restrictions have been forgotten; observers familiar with the practical operation of both the public and the private phases of the construction industry have raised their voices in criticism of W.P.A. policies.

An excellent opportunity seems to be open to the Works Progress Administration to get out of the construction business. That could not be done abruptly, but it might be accomplished in reasonably good time. As rapidly as states and municipalities become able to finance their own construction work, heavy construction could and should return to the less expensive competitive procedure of the construction industry. Even when political subdivisions can only partially finance their work, their applications could be referred to government lending agencies for funds to make it possible to have the work done under normal conditions.

Public Works Administration

Public Works Administration officials privately agree among themselves that P.W.A. may really be nearing the end of its days as a spending or pump-priming agency. Plans are actually being made to reduce gradually its activities to the point where they may be handled by a skeleton organization. Unless demands develop for the continuation of an enormous program for the construction of emergency public works, it is proposed that as P.W.A. projects now under way are completed, the Public Works Administration should turn to the liquidation of its business and the consideration of plans for future public works which are not to be used unless and until there is another emergency demand for public employment and the stimulation of industry such as might be occasioned by an economic depression.

Political and business observers in Washington remember similar reports and doubt that the Federal Government is really approaching such a radical change in policy, although they do not question the intention to end large-scale spending by the emergency agencies. It is more or less generally believed that the expenditure of the larger appropriations is likely to be continued by established departments and permanent agencies through which demands for federal funds are usually made. Since such activities are less obvious to the public eye, they are more likely to be continued and to contribute to an unbalanced national budget than might have been permitted among the temporary spending agencies.

Even though the Public Works Administration should not get additional funds, it still has $1,000,000,000 in unfinished projects and commitments to complete. The newly created U. S. Housing Authority may take some of that away, but such loss would be more than offset by unfinished financial P.W.A. business with scores of political subdivisions. As a matter of fact, the last Congress extended the life of the Public Works Administration through June 30, 1939, and provided additional funds for projects which are sure to continue up to that date. It, therefore, follows that while P.W.A. may not make any more grants and loans, the organization is not going entirely out of existence without further notice.

Section 206 of the Public Works Extension Act of 1937 bars the Public Works Administration from accepting applications on projects for the first time since June 16, 1933. As P.W.A. closes its books to new business and turns all public construction back into normal channels, it is interesting to note the proportions of the work which it has been doing. More than 25,000 applications have been filed for projects involving over $7,000,000,000 in grants and loans and an estimated total construction cost in excess of $10,000,000,000. Less than one half of those applications were approved and actual costs appear reasonable in comparison with other phases of emergency construction undertaken to provide work and revive business.

United States Housing Authority

United States Housing Authority became a reality with the signing of the Wagner-Steagall Public Housing Bill by President Roosevelt on September 3, 1937. Numerous amendments were offered and many changes were made during the three years in which legislation for creating the Authority was under consideration. In final form, the Act gives the Secretary of Interior general supervision of the United States Housing Authority but vests the real power of the Authority in "an Administrator to be appointed by the President by and with the advice and consent of the Senate." The Administrator is to be permanently appointed for a period of five years at a salary of $10,000 and is forbidden to engage in any other business.

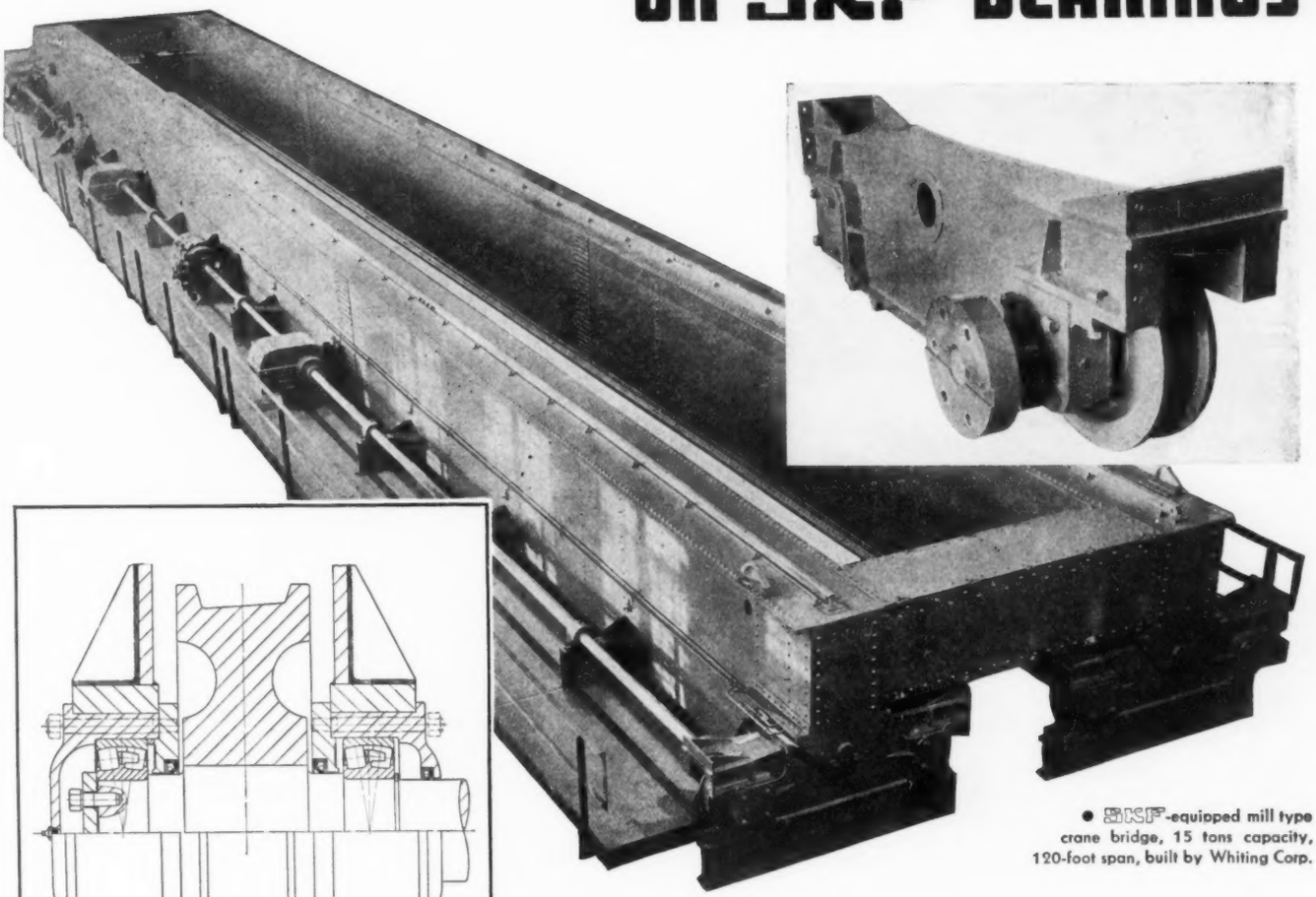
A half billion dollars is to be entrusted to the Administrator with very few restrictions. In addition, the President may, at any time within his discretion, transfer to the Authority any right, interest or title held by any department or agency of the Federal Government in any housing or slum-clearance project, including unexpended balances of funds heretofore allocated for such purposes, and employees engaged in housing or slum clearance. The Authority may continue any or all activities undertaken in connection with projects thus transferred to it from other agencies. The Authority may also accept and utilize voluntary and uncompensated services of employees of federal, state, and local governments found desirable in the performance of its duties.

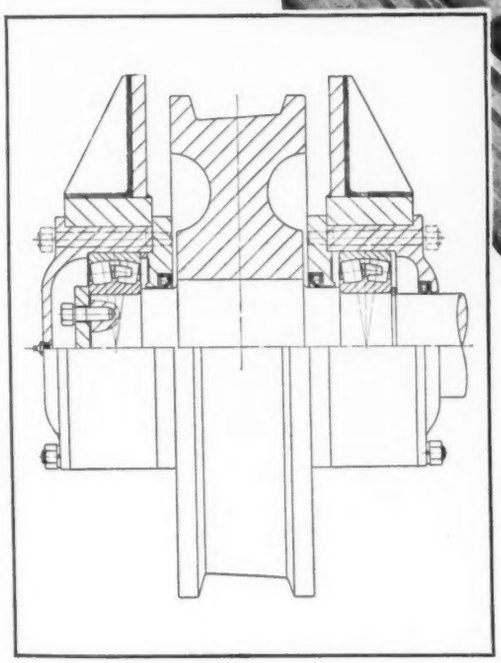
Council has endeavored, through its contacts, to exercise an educational influence to get government housing on a sound business basis, and proposes to cooperate with the new Administrator and staff of the United States Housing Authority as soon as the Authority is ready for business, but Council's staff has refrained from becoming involved in the propaganda and behind-the-scenes struggle for the Administrator's position. In the spirit of helpfulness, however, the following statement was made to President Roosevelt who has expressed his appreciation for the views of engineering organizations:

(*Continued on page 886*)

CRANES EARN PROFITS

ON SKF BEARINGS





● SKF-equipped mill type crane bridge, 15 tons capacity, 120-foot span, built by Whiting Corp.

● The ability of SKF Bearings to align themselves enables them to give profit-paying performance on this Whiting bridge track wheel—long axle.

No matter whether the truck is unloaded or carrying the full working load, SKF Bearings compensate for any deflection that may occur.

One bearing is held laterally while the other is free endwise—and both are easy to assemble and disassemble. Result: high load carrying capacity . . . long life . . . low operating costs. If *you* want the right bearing in the right place, specify SKF.

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3953

SKF ROLLER BEARINGS

"Engineers appreciate the difficulty involved in choosing an Administrator for the United States Housing Authority and wish to assure you of their support in your selection of an experienced executive, for this vitally important position, who is not only technically qualified for such responsibility, but also possessed of sound judgment and practical knowledge developed from dealing with nation-wide business problems of similar nature and magnitude.

"Several branches of the engineering profession in the United States are thoroughly familiar with the housing situation. Many engineers are engaged in public and private housing enterprise, and some are well-known authorities on urban planning which involves the elimination of unsafe and insanitary housing conditions. The American Engineering Council is in a position to express the united opinion of a majority of such engineers of this country and will welcome all opportunities to be of service to you and to the Administrator of the United States Housing Authority."

Government Reorganization

SINCE it is much easier to secure constructive modification of legislation before passage than to obtain revision afterward, some observers feel that it is for the best that no action was taken on government reorganization in the confusion which obtained during the hurried days of the last session of Congress. The delay gives citizens time to investigate the proposed reorganization program and to express their opinions to members of Congress. It also affords an opportunity for the reorganization committees of both Houses to agree upon legislation more likely to effectively serve the purpose. Council, therefore, invites the attention of member societies to the following facts regarding the present status of government reorganization ideas and legislation.

Congress left S.2970 and H.R.7730, H.R. 8202, H.R.8276, and H.R.8277 on its calendars as proposals for the reorganization of the Federal Government of the United States. S.2970 was introduced by Senator Brynes of South Carolina, to reduce resistance to the original proposition for reorganization, after the hearing on S.2700 which had been sponsored by the late Senator Robinson from Arkansas. It was referred to the Select Committee on Government Reorganization in the Senate, which reported it back to the Senate without amendment and with the recommendation that it should pass.

H.R.7730, introduced by Robinson of Utah, providing the President with six administrative assistants was reported to and passed by the House without hearings but failed to receive consideration by the Senate. H.R. 8202, introduced by Warren of North Carolina, giving reorganization power to the President and creating a Department of Welfare was reported to the House without a hearing and passed to the Senate where it was referred to the Senate Committee on Reorganization. H.R.8276, introduced by Vinson of Kentucky, creating a general auditing office, and H.R. 8277 introduced by Mead of New York, to revamp the Civil Service System, were reported without hearings and left on the calendar of the House at the close of the session. None of the reorganization bills have had consideration by a Joint Committee of the House and Senate, but such a meeting of minds must be held before there can be reorganization.

Copies of the hearings on Robinson's S.2700, the report on S.2970 to the Senate by Chairman Byrnes, and Byrnes' S.2970 may be secured by writing to the Select Committee on Government Organization of the United States Senate, Senate Office Building, Washington, D. C. Copies of the Bills introduced in the House and the "Remarks by Members of the Select Committee of the House on Government Organization" may be obtained in the same way from the Select Committee on Government Organization of the United States House of Representatives, House Office Building, Washington, D. C. A limited number of copies of the reports of the several committees which have studied the situation are also available through the same sources.

Engineers and engineering societies wishing to exercise their rights to advise members of Congress on this vitally important issue should get in touch with members of Congress while they are at home, and indicate their wishes by appropriate resolution addressed to Senator James F. Byrnes of South Carolina, Representative John J. Cochran of Missouri and to the members of the House and Senate from their respective states. Council will be glad to have copies of all such communications for the information and guidance of officers, staff and committees who may be called upon for expressions of engineering opinion by the investigating committees and members of Congress.

Positions Available

Engineering Societies Employment Service

DESIGNER thoroughly familiar with machine-design practice as well as principles of electrical engineering and design. Sufficient experience to design mechanical parts of new hub mechanism consisting primarily of high-ratio reduction gearing, and to incorporate in design such equipment as small, high-speed electric motors, limit switches, etc. Apply by letter. Location, New England. Y-2311.

GRADUATE MECHANICAL ENGINEER for design and research. Must have 10 years' experience in heavy machinery, such as cranes, etc. Salary, $300–$350 a month. Apply by letter. Location, Pennsylvania. Y-2298.

GRADUATE MECHANICAL ENGINEER, young, to act as assistant to factory manager. Must have actual machine-shop practice, as well as drafting and designing experience. Experience with graphic charts desirable. Position may include some production-control work. Opportunity. Salary, $100–$150 a month to start. Apply by letter. Location, New York State. Y-2278.

DRAFTSMAN, mechanical engineer with experience in dust-collecting layout. Apply by letter. Location, New York, N. Y. Y-2271.

MECHANICAL ENGINEERS, one or two, young, with oil-country production experience. Salary, $175–$250 a month. Apply by letter. Location, South. Y-2268.

INDUSTRIAL SALES ENGINEER, 30–35. Will work in close cooperation with sales manager of company selling equipment to industrial trade. Must have sales experience, preferably in industrial-equipment field in New York Metropolitan area. Salary, $175 a month to start. Apply by letter. Y-2264.

MECHANICAL ENGINEER to direct maintenance and improvement in paper-mill machinery, boiler plant, etc. Salary, $3000–$4000 a year. Apply by letter. Location, Pennsylvania. Y-2253.

MECHANICAL ENGINEER to handle production control and personnel work for furniture manufacturer. Must have the analytical and engineering ability required to find and correct bottle necks in production, evolve methods to reduce lumber waste, perfect gluing practice, improve varnish drying, improve heat and power balance, determine means of coordinating departments and educating workmen to better methods. Salary, $3000–$4000 a year. Apply by letter. Location, Pennsylvania. Y-2252.

MATERIALS ENGINEER, graduate mechanical engineer. Duties will be to develop specifications and material standards, and test and inspect materials in connection with products used in maintenance and construction of petroleum refineries. Apply by letter. Location, New York, N. Y., Area. Y-2203.

DIVISION PRODUCTION MANAGER, 30–40, for company manufacturing varied line of mechanical equipment, machine-tool type. Must have industrial-engineering degree or equivalent in practical experience, and at least five years' experience in scheduling, planning, plant-order, and inventory control. Salary, $3000–$4000 a year. Apply by letter. Location, Ohio. Y-2230-C.

CHIEF ENGINEER, 38–45, graduate mechanical engineer for designing division of company manufacturing varied mechanical equipment. Department consists of about 20 designers and draftsmen. Must have at least five years' experience as assistant or chief design engineer of mechanical-equipment line, and should now be employed as assistant or chief design engineer of substantial company manufacturing mechanical equipment. Salary, $5000–$7500 a year. Apply by letter. Location, Ohio. Y-2229-C.

MACHINE DESIGNERS, preferably with rolling-mill experience. Apply by letter. Location, Pennsylvania. Y-2217.

(*Continued on page 888*)

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Teeth, not tension. That's the performance secret of Morse Silent Chain Drives' greater efficiency. • Smooth, positive, even flow of power from motor to machine is assured with Morse Chain Drives. No slipping, no binding. Morse Chains' multiple teeth grip and turn with sure ease and efficiency. All your power is productive power with Morse Chain Drives! • They're better—yet Morse Chain Drives actually cost no more. Ask the Morse man in your territory, or write MORSE CHAIN COMPANY, ITHACA, N. Y. • *Division Borg-Warner Corp.*

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CENTRIFUGAL PUMP DESIGNER, about 35. This experience is essential. Apply by letter. Location, California. Y-2212.

PLANT SUPERINTENDENT for job welding shop employing 350 men and manufacturing refinery equipment. Experience in welded pressure vessels is essential. Apply by letter. Location, South, Y-2142.

PERSONNEL MANAGER, graduate mechanical engineer with personnel experience with large company. Apply by letter. Location, New York State. Y-2045.

INDUSTRIAL ENGINEERS, 3, preferably mechanical, ages 30–40. Must be able to make department layouts and arrange machinery and equipment to secure best sequence of operation. Must understand material handling and conveying, and should have working knowledge of machine design and development. Salary, $225–$275 a month. Apply by letter. Location, Middle West. Y-1965.

INSTRUCTOR with six years' experience, to teach acetylene and electric welding. Salary, $1800–$3800 a year. Apply by letter. Location, New Jersey. Y-2115.

PERSONNEL DIRECTOR with wide personnel experience embracing employment, safety, time-study, job analysis, wage-payment systems, etc. Apply by letter. Location, Middle West. Y-2347-C.

DRAFTSMAN with experience in steam turbines and centrifugal pumps. Apply by letter. Only an engineer residing within commuting distance of New York, N. Y., will be considered. Y-2343.

SALES MANAGER with sound merchandising ideas and proved ability to organize and handle national sales force for well-established manufacturer of light machinery, selling through two major distribution outlets, machinery and hardware stores. Must be able to develop definite, workable sales policy and show results. Excellent possibilities for man with initiative and knowledge of markets and men. Salary, $7000–$10,000 a year. Apply by letter giving detailed information. Location, N. Y. Metropolitan Area. Y-2333.

ASSISTANT PROFESSOR to teach mechanics, strength of materials, materials laboratory, and hydraulics. Must have done graduate work or have teaching experience in up-to-date hydraulic laboratory. Salary, $2100 for nine months' service. Apply by letter. Location, South. Y-2328.

MAINTENANCE SUPERINTENDENT, 30, with engineering training. Must be thoroughly experienced in all phases of factory maintenance work, including shop and buildings, and be practical shop worker as well as capable of planning and directing the work, purchasing necessary equipment and supplies. Metal-treating company. Apply by letter. Location, Pennsylvania. Y-2322.

HEATING ENGINEER with experience in mechanical equipment of buildings, such as pumps, refrigeration, etc. Position is with real-estate company. Apply by letter. Location, New York, N. Y. Y-2316.

DESIGNER with experience in domestic oil-burning equipment. Apply by letter. Location, New York, N. Y. Y-2314.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after November 26, 1937, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers at once.

NEW APPLICATIONS

ABORN, ROBT. H., Kearny, N. J.
ALLEN, EDW. K., JR., Worcester, Mass.
ASBURY, A. D., Greenville, S. C. (Rt & T)
BLACK, PAUL H., Ithaca, N. Y. (Re)
BLADE, ELLIS, New York, N. Y.
BOCHMANN, B. E., Cedar Rapids, Iowa
BOURNE, WM. H., Larchmont, N. Y.
BUCKIUS, ORLAND E., Berkeley, Calif.
CHAVE, CHAS. T., New York, N. Y.
COWAN, MAJ. P. J., London, England
DIAKOFF, ALEXIS J., Grand Forks, N. D. (Rt & T)
EGHOIAN, VAHAN, San Francisco, Calif.
FORD, ALBERT D., Albuquerque, New Mex.
HEFTLER, PAUL, Grosse Pointe Park, Mich.
HOMAN, WALTER, Dayton, Ohio
KENNEDY, ANDREW M., San Francisco, Calif.
KERWIN, W. A., Chicago, Ill. (Re)
LAMBIE, AARON L., Pittsburgh, Pa.
LINDQUIST, ALFRED H., Los Gatos, Calif.
LUNEY, E. ROSS, Peoria, Ill.
MACAULEY, J. B., JR., Detroit, Mich.
MARTIN, HARRY D., Bristol, Conn.
MCKIMMEY, J. A., St. Joe, Ark.
MERRITT, THEO. R., Yonkers, N. Y. (Re)
MOSS, W. WADE, JR., New York, N. Y.
OONK, WM. J., St. Louis, Mo. (Rt & T)
PASK, A. H., Windsor, Ont., Can.
PETERSEN, P. E., Waterbury, Conn.
POLLAK, RUDOLF, Scarsdale, N. Y.
QUAS-COHEN, C. M., Manchester, England
RIJK, N., Leiden, Holland
SAUERBRUNN, EDW. S., Cincinnati, Ohio
SCHUTZ, HAROLD R., Toledo, Ohio
STAMP, ALFRED T., Washington, D. C.
STEIN, I. MELVILLE, Philadelphia, Pa.
STEVENS, W. W., JR., San Francisco, Calif.
STUDLEY, G. L., Walpole, Mass.
TARZY, THOS. J., NORTH BERGEN, N. J.
TYNAN, JAS. W., Newark, N. J.
VAN VALKENBURGH, R. M., Chicago, Ill.
WALDREP, JAS. E., Greenville, S. C.
WEBB, THOS. C., Tulsa, Okla.
WYATT, JOHN D., Cincinnati, Ohio
ZAUNMILLER, EDW. W., New York, N. Y.

CHANGE OF GRADING

Transfers from Member

CLARK, FRANK S., Boston, Mass.
MYERS, DAVID MOFFAT, New York, N. Y.

Transfers from Junior

AINSWORTH, JOHN R., Wilmerding, Pa.
CAMPBELL, DAVID S., New York, N. Y.
DAM, CYRUS K., San Francisco, Calif.
DESTIN, P. T., San Francisco, Calif.
EVERETT, FRANKLIN L., Ann Arbor, Mich.
GRANDINETTI, JOHN R., Philadelphia, Pa.
LAUDIG, JOHN B., Pittston, Pa.
MAYERS, M. A., Pittsburgh, Pa.
OATLEY, HENRY C., Bellerose, L. I., N. Y.
O'MARA, RICHARD F., Los Angeles, Calif.
PIERCE, JAS. E., Midland, Mich.
STEINER, WALTER A., Cleveland, Ohio
STOEVER, H. J., Philadelphia, Pa.
WEIR, GEO. E., Richmond Hill, N. Y.

A.S.M.E. Transactions for October, 1937

THE October, 1937, issue of the Transactions of the A.S.M.E., contains the following papers:

Operating Experiences in the Steam and Power Department of the South's First Alkali Plant (FSP-59-11), by G. R. Avery

A New Low-Alloy Pearlitic Steel for High-Temperature Service (FSP-59-12), by C. L. Clark and R. S. Brown

Power and Forces in Milling S.A.E. 3150 Steel With Helical Mills (MSP-59-2), by O. W. Boston, W. W. Gilbert, and K. B. Kaiser

Determining the Tool-Life-Cutting-Speed Relationship by Facing Cuts (MSP-59-3), by C. E. Kraus and R. R. Weddell

Analyzing Variable Loads in Steam- and Diesel-Power Plants (OGP-59-4), by G. C. Boyer

Experimental Investigation of the Influence of Tube Arrangement on Convection Heat Transfer and Flow Resistance in Cross Flow of Gases Over Tube Banks (PRO-59-6), by O. L. Pierson

Experimental Investigation of Effects of Equipment Size on Convection Heat Transfer and Flow Resistance in Cross Flow of Gases Over Tube Banks (PRO-59-7), by E. C. Huge

Correlation and Utilization of New Data on Flow Resistance and Heat Transfer for Cross Flow of Gases Over Tube Banks (PRO-59-8), by E. D. Grimison

Industrial Instruments, Their Theory and Application (PRO-59-9), by Ed S. Smith, Jr., and C. O. Fairchild

Abstract of Progress Report No. 3 on Heavy Helical Springs (RP-59-8), by C. T. Edgerton

Air Resistance of Railroad Equipment (RR-59-4), by A. I. Lipetz

DISCUSSION

On previously published papers by Messrs. H. L. Daasch; N. Fodor; and V. F. Estcourt